POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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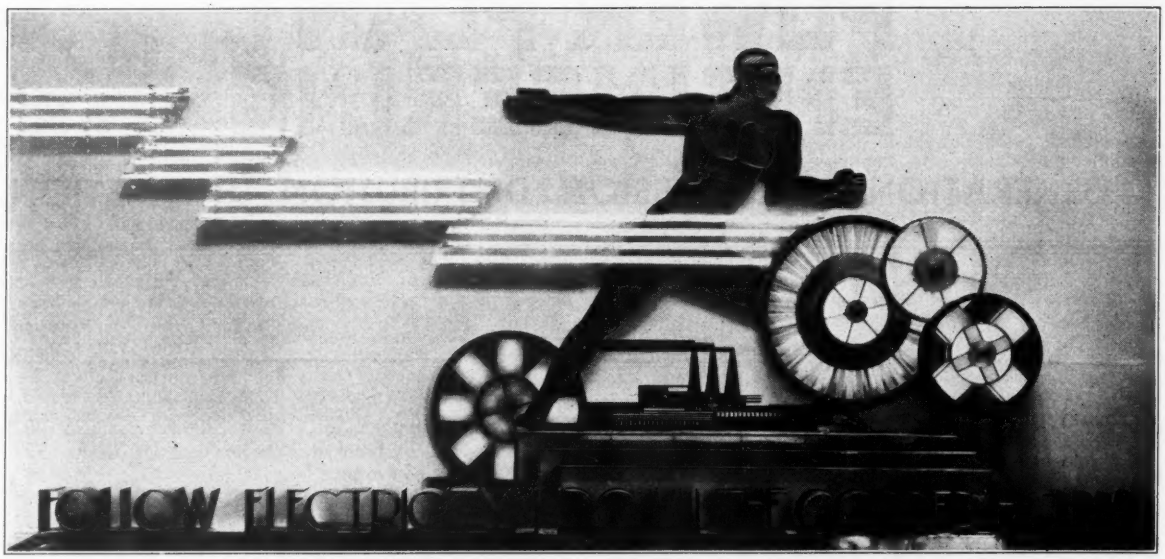

ELECTRICITY AT WORK

PICTURED HERE IS THE mural at the entrance to the exhibit of the electric light and power industry at the Century of Progress in Chicago. It symbolizes, "Electricity at Work"—a copper man reaching out into space, directing ether waves through his body into a fantastic rotating wheel of color and then down through a modern power station and on through the copper highways for utilization.

One does not have to stand in front of this mural, however, to see electricity at work at the Century of Progress. It is at work everywhere; indeed, there is scarcely any place in the whole exposition where electricity is not at work in a thousand different ways. With the exception of the boys pushing tired business men around in wheel chairs or pulling nice young ladies in rickshaws, electricity seems to do all the work. Nothing is done by hand. Lights flash on and off, doors open and close, drinking fountains spurt, lectures are delivered, motion picture programs go on and off, all without the aid of the human hand or voice—electricity does it all.

Naturally, behind such a scene of intense electrical action there must lie an electrical transmission and distribution system of considerable proportion and to the electrical engineer, at least, the design and construction of this system is perhaps of even greater interest than many of the trick photoelectric exhibits at the Fair which so intrigue the general public. For, after all, the modern engineer is fully familiar with the ramifications of photoelectric phenomena and has ceased to be amazed at new applications.

The electric power supply system at the exposition, is decidedly unique and presents many features entirely new and untried before. As pointed out in the article describing this system, on page 292 of this issue, the design and construction of a transmission and distribution system for an institution equivalent to a city of 60,000 and which is destined to have a life of only five months, involves practices and principles radically different from the conventional. It is because of its many novel features that we present an article on this system.

The Century of Progress, however, has no monopoly on revolutionary developments and departures from conventional practices. Consider, for example, the new power plant of Jacob E. Decker & Sons, described in the leading article of this issue. Here is a development representing quite as revolutionary a departure from traditional packing plant engineering and financing as anything to be found at the Fair. Four features of this plant command unusual interest; first, the self liquidating plan by which it was financed without affecting the working capital or credit of the company; second, modernization yet effective utilization of existing equipment; third, balanced steam and electric loads under all conditions; and fourth, a revolutionary step in the packing plant which has shown great savings. We are tempted to tell you more about it here but perhaps you had better turn over the page and read the complete article yourself.

In a preceding paragraph we mentioned photoelectric phenomena. We did not intend getting back on this subject but it just occurred to us that we have an article on the "electric eye" in this issue which should be of particular interest to the readers of this magazine since it shows the use of photoelectric devices in the power plant. Most engineers by this time are quite familiar with the ordinary photo electronic cell, but recently a more simple device known as the photronic cell has been developed and this device is quite as effective for power plant applications as the more complex photoelectric vacuum tube. At any rate, the various types of photoelectric devices available today are all discussed in this article and after reading it, you should be better able to select the particular type best suited to your requirements.

WITH THE EDITORS

Prepare for Business Upturn

AFTER SEVERAL years of decline in practically all lines of business and many months of horizontal activity, business survey curves have taken an upward hook in recent weeks that is more than welcome to everybody. Reports of the Edison Electric Institute show that the power generated in the utilities of the country during the week ending June 17 was 9.5 greater than the corresponding week of last year, the crossing of the curves taking place about the first of May. Business activity in general reached its low point during the latter part of March, crossed last year's curve about a month later and is still headed in the right direction. Almost exactly the same thing can be said in describing the production curves of steel ingots and automobiles. Freight car loadings for May came up to and followed last year's curve which is considerable advancement from the lowest point reached last December. Commercial failures are, in number, only a trifle above the 1923-1925 weekly average, while the daily average of construction contracts awarded is still considerably below last year's value an upturn in May from a long horizontal run is another encouraging indication.

To the engineers of power plants of every description these indications sound a warning to prepare for growing loads and expanding services. Many changes in process have been made during the period of inactivity and the engineers in industrial plants will be faced with many new problems. Delay in getting adequate service from the power plant may be the handicap that will put a particular company at a disadvantage in a growing market. In this problem the engineer must take the initiative in preparation for prospective services.

Science, Strong Armed Greeks, Gears and Artistic Expression

SOMEHOW, as we look at the picture shown on the opposite page, we cannot help wondering what the husky brute at the right is thinking of and what he is supposed to be doing. The artist insists that he is directing ether waves from out in space into the power plant for further distribution to the points of utilization. Well, maybe so, but we have been playing around with the so-called ether waves for considerably more than half of our lives and we have never been able to do a stunt like that with them. As to what he is thinking about, judging from the size of his flat top head, it can't amount to very much—he does not appear capable of any considerable amount of intellectual effort. However, since he is probably only a sort of traffic cop for ether waves, perhaps he does not require any better mental equipment than that of the average traffic cop.

As a symbolism, and considering that it is made largely of copper and glass, this mural is not bad, indeed it is considerably better than most artistic interpretations of scientific and engineering achievement, but the question which it raises in our minds is this: Why, when a modern artist endeavors to depict some scientific or engineering achievement is it necessary almost invariably to introduce the figure of a ninth-rate moron waving his arms in some mysterious fashion? And why must there always be a couple of gears floating around in the picture? Invariably when the artist attempts to interpret or symbolize anything in the mechanical or scientific field, he manages to work in a couple of gears of some kind. And usually in the midst of these gears there is shown a swarthy blackamoor or other lantern jawed creature in some state of disrobement.

From this it must not be inferred that we are prudes, afflicted with a false sense of modesty. Indeed, we feel that our tendencies are quite the opposite but our first requisite in a painting or a piece of sculpture or indeed of any kind of artistic expression is grace and beauty, and when figures portrayed in these works lack these qualities the least the artist could do is add a few clothes.

It seems to us that the modern artist who wishes to interpret science and technical development might at least make some attempt to find out what it is all about. He should know by this time that there are other devices in engineering besides gears and levers. And he should know also that it is not brute strength but high mental development which is responsible for our scientific and technical progress. They might at least draw figures showing some brain capacity. The average artist's interpretation of engineering achievement consists of a strong armed Greek wildly pulling levers in an atmosphere of gears.

We make no claim of being artists but it seems that the almost endless variety of delicate laboratory equipment which are the tools of modern science and the geometrical beauty inherent in modern conceptions of the atom and fields of force, should furnish some inspiration to the artist in his delineation of science on canvas or otherwise. Anyone, however, meagerly endowed with artistic temperament who has ever looked into a spectroscope or who knows something of the structure of atoms as revealed by the x-rays spectrometer, or even one who has only contemplated the beauty of the mathematics which lies at the root of all science and engineering. must know that there is more to scientific achievement than misshapen hulks of humanity pulling levers. In the conception of the lines of force surrounding charged bodies there are great possibilities for artistic expression. Yet the modern artist ignores practically all of these things.

At the Century of Progress there are a number of places where murals showing the progress of science are used, but in practically every instance they are subject to the criticisms here presented. With few exceptions all of them contain ridiculous figures such as only Rube Goldberg should be licensed to draw and few of them show any more originality than a 12 year old schoolchild would display. In some instances the beauty of the materials used offsets to some extent the shortcomings of the artistic conception but that only renders this criticism more justifiable. We sincerely hope that some day an artist will come along who will penetrate the true beauties of scientific achievement and delineate them intelligently and accurately for the benefit of all mankind.

POWER PLANT ENGINEERING July 1933

"A NEW DEAL" in Indus

Jacob E. Decker & Sons Power Plant Built on Self-Liquidation Plan Is a Revolutionary Departure from Traditional Packing Plant Engineering and the Unique Financing Arrangement Opens Up New Avenues to Industrial Power Plant Expansion

PERHAPS at no period in the commercial history of this country has the question of industrial power supply been of greater importance. Decreasing consumption, keen competition, low inventories, improved equipment and better engineering combine to make modern, reliable and economical power facilities a necessity. A power plant even a few years old is a potential source of revenue which can no longer be set aside with the excuse that power is an inconsequential part of the total manufacturing cost. True as this is in most cases, it is probable that the potential savings in many industrial power plants is equal to the net revenue of the company, while it has been demonstrated that savings brought about through a new plant have paid the dividends during these critical times of close competition.

Conditions vary from industry to industry and from plant to plant so that no set program can be followed. Sometimes purchased power, sometimes a Diesel engine or a combination of purchased and generated power is advisable while those industries that utilize considerable process steam often find substantial economies in generating their electric power and using the exhaust steam in process work.

Representative of the last classification is Jacob E. Decker & Sons, pork packers of Mason City, Ia., where a new high pressure power plant is writing the first page in what has been called a new chapter of industrial power plant expansion. Four features of the plant command unusual interest: the self-liquidating plan by which it was financed without affecting the working capital or credit of the company; modernization by superimposing proven high pressure equipment on the old plant, yet utilizing the old machinery effectively in the program so as to give a minimum investment; the balanced steam and electric power arrangement maintained under all load conditions by the unusual flexibility of the design (which at the same time allows unlimited freedom for future expansion); a revolutionary step in the packing industry which has already shown operating steam and power costs per head ½ to ⅓ of former cost in a plant which even at that time gave unit costs about ½ of those quoted for the packing industry at large.

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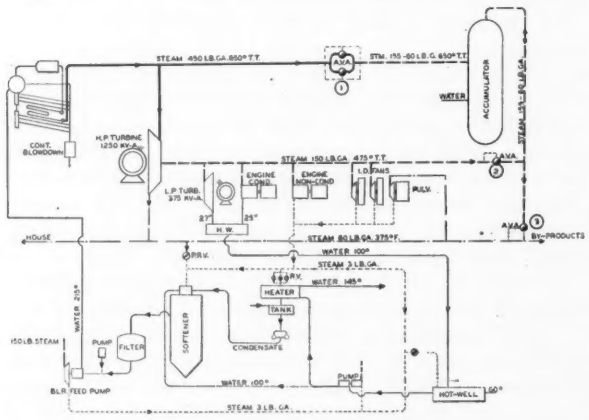


FIG. 1. FLOW SHEET OF THE NEW PLANT

Financial Arrangement

Of these four, perhaps the method of financing is the most important as industrial concerns are loath to tie up capital in power plant construction and without money appropriations even the best engineering plans are of no avail. Space does not permit a detailed history of the development but because of the unique arrangement, which is undoubtedly destined to play an important role in the next few years, a few paragraphs are advisable.

Preliminary surveys were made in 1929 by Ralph D. Thomas & Associates, Consulting Engineers, for the purpose of determining the advisability of extending the 150 lb. boiler plant and continuing to purchase power, or of building a new high pressure power plant to produce both steam and electricity. The first program would have required one new boiler immediately and a second in 1934 at an estimated cost of $129,140 for the two units. A high pressure plant with the necessary generating equipment was estimated at $262,240, a figure surprisingly close to the construction cost of the plant as built later. Under the most adverse conditions of operation and 1930 production the survey indicated that the application of 450 lb. steam through non-condensing turbines could produce all the power requirements, as a by product of the steam demand, with less fuel than was formerly required to produce process steam alone.

In spite of the attractive economies of the proposed plant and strong financial position of the Decker Company, the contraction of credit subsequent to October, 1929, made the company hesitate to devote working capital to other than market operation of their business. Negotiations proceeded, however, and December 5, 1931, an agreement was entered into by which Power Service Corporation agreed to underwrite the installation on the basis of a lease contract, the Decker Company to operate and maintain the plant with its own crew and pay all fuel, labor, repair, insurance, and tax costs. The agreement fixed a base price but was sufficiently flexible to

ustrial Power Supply

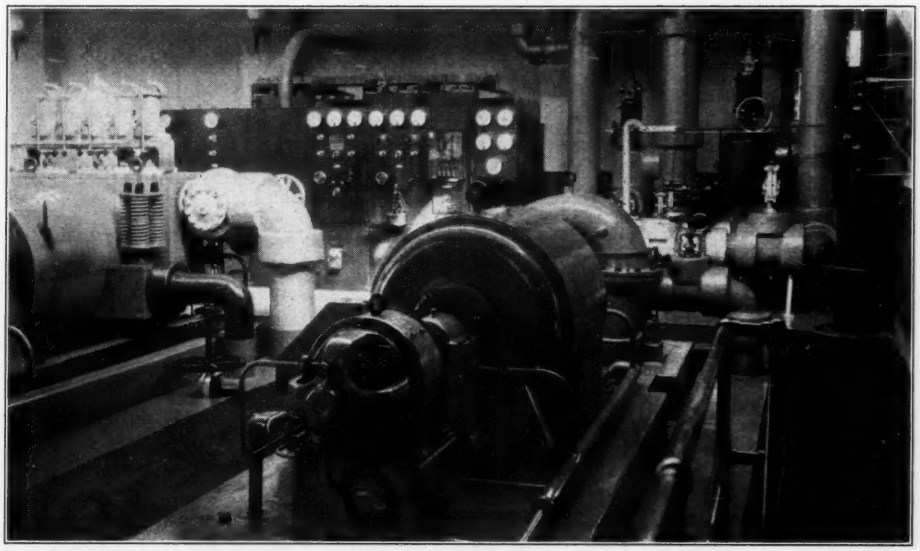


Fig. 2. The Turbine Gallery with the Large Bleeder Turbine on the Left and the Accumulator Control Valves in the Upper Right Hand Corner

allow desirable changes in equipment or design if agreeable to all parties. Construction was started in February, 1932, and the plant put in service August, 1932, at which time purchased power was discontinued and Master Mechanic George E. Moeser and Chief Engineer John A. Young took the plant over from the contractor.

Operation has been entirely satisfactory with exception of one minor interruption about two weeks after starting operation, which was then utilized for inspection and adjustment. Mr. Moeser can boast that in the thirteen years he has been master mechanic there has not been a single power or mechanical interruption making it necessary to stop work long enough to send the men home. In a packing plant with an annual consumption of approximately $65,000 worth of power and $80,000 worth of coal, this is indeed an enviable record. With the new plant there is little likelihood of this long time record terminating.

Because of several small unrelated construction contracts which were included as a matter of convenience, the actual cost of the plant is difficult to determine exactly. The total cost including these and the accumulator, which was not contemplated in the original survey, but exclusive of engineering fees, was about $288,000 divided as shown by Table I. Monthly lease payments are substantially equal to the former purchased power bills and at the end of a five year lease period the Decker Company has the option of purchasing the plant for $25,000.

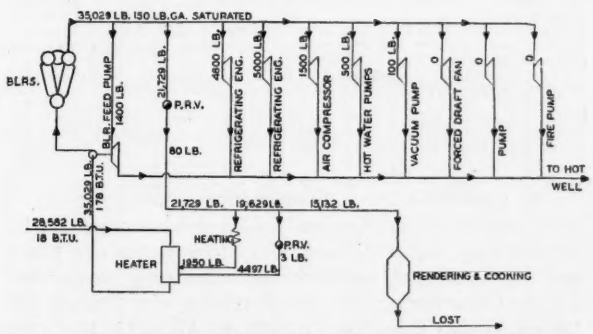


FIG. 3. HEAT BALANCE OF THE OLD PLANT FOR AVERAGE CONDITIONS

Unique features of the plan are that while Power Service Corporation is the owner of the plant during the lease period, the design and equipment selection has been made by the consulting engineers, Ralph D. Thomas & Associates, under the direct supervision and coöperation of Jacob E. Decker & Sons who have been assigned all guarantees and performance contracts. This coördinated effort of private capital, adequate engineering, reliable contracting and capable operation, each in its own sphere on a strictly business basis, is unique in the history of industry and should not be confused with the commonly called "guaranteed savings plan" or "manufacturers financing arrangements." Payments are in no way related to fuel consumption, fuel cost or power demands, the total payment over a period of years being based solely upon the construction cost of the plant plus engineering fees and carrying charges, with the term of payment extended to such a date that the monthly rental approximated the average power bill. Equipment was selected to meet the requirements of careful engineering, the financial arrangement being such that there was no need to make the engineering meet the needs of miscellaneous preferred equipment.

Power Service Corporation elected to sell the Decker lease to the First Bancredit Corporation, and in order that the First Bancredit Corporation would be assuming no responsibility in connection with performance guarantees, etc., they required agreements from the contractor and manufacturers guaranteeing the lease payments; this responsibility being pro-rated in the ratio of monies received to the total cost of the plant. It is this feature which has undoubtedly led to the prevalent but erroneous rumors that the plant was financed coöperatively by manufacturers.

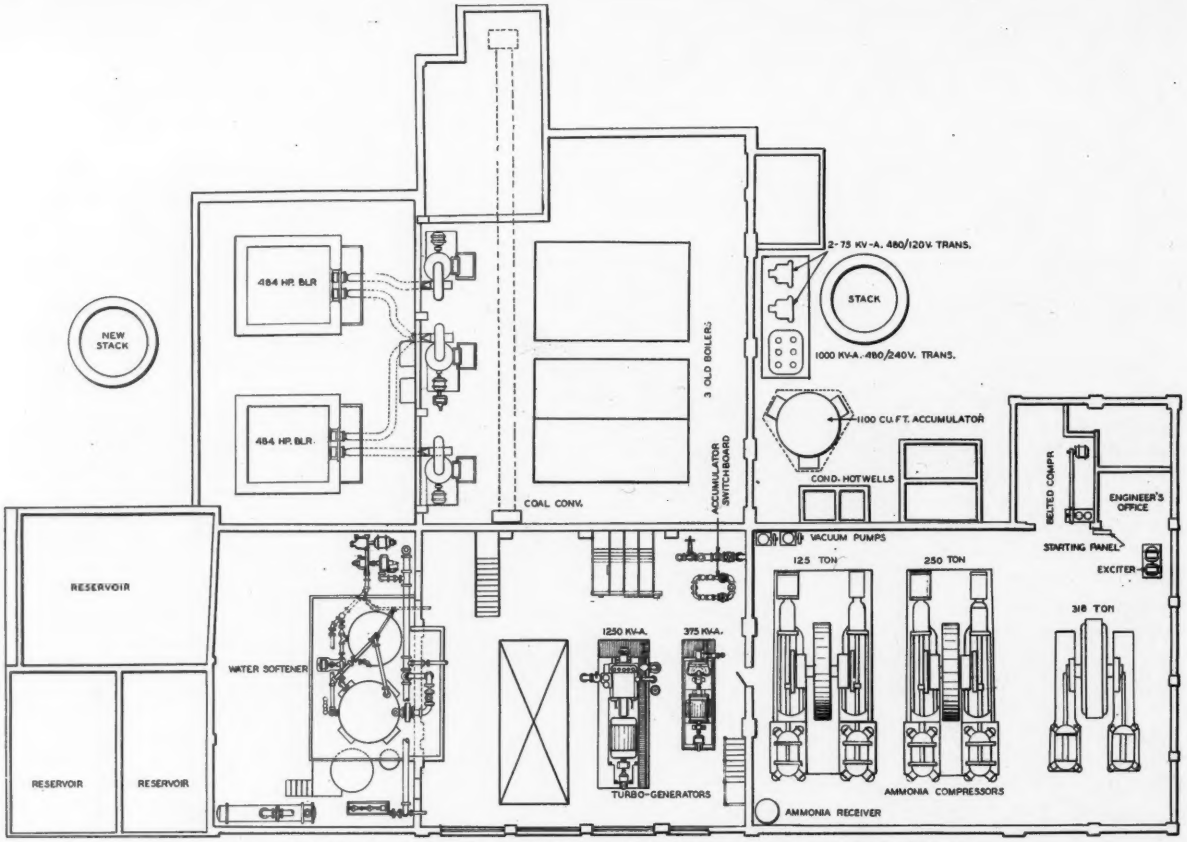


FIG. 4. PLAN OF THE PLANT SHOWING BOTH OLD AND NEW EQUIPMENT

As far as the Decker Company is concerned, the financial success or self-liquidating feature of the plan, is, of course, predicated upon continued activity in the pork packing industry on at least a 1930 basis. As a matter of fact, the past three years' activities show a decided increase well in agreement with predictions made by the 1929 preliminary survey from records extending back to 1917. At that time it was thought that by 1937 the probable economic limit of a single killing floor, 900,000 hogs annually, would be reached. Indications are that these assumptions will be justified as far as hogs are concerned, although power and steam requirements will differ from the original estimates because of a beef killing floor now under construction and which will add materially to the electric load.

TABLE I. DIVISION OF INVESTMENT

Boilers	28.80%
Firing equipment	6.70%
Boiler feed pumps, drives and regulators	2.00%
Draft fans and drives	2.00%
Boiler room metering equipment and controls	1.45%
Water softener equipment	4.35%
Steam accumulator	10.20%
Turbo-generators	13.60%
Switchboard, transformers and wiring	4.85%
High and low pressure piping	12.00%
Concrete chimney	1.40%
Structures, foundations and building alterations	12.65%
Total	100.00%

In addition to the elimination of the purchased power bills, which about balances the lease payments, fuel savings from increased boiler efficiency due to larger, more modern boilers; a more even boiler load due to the steam accumulator; lower process pressures and quicker cooking periods because of the superheat, are considerable, in fact, justification in themselves for the new plant. During the fifth period of 1933 (the plant works on the basis of thirteen 28 day periods a year beginning November 1) 10 per cent more poundage was handled than in the similar period of 1932, and 160 tons less coal was burned. During the sixth period the record was even more striking, 60 per cent more poundage being handled with but 35 tons more coal burned. When it is considered that the 1933 operation includes some 400,000 kw.-hr. of electric power a month (all purchased power bills were eliminated), and that both steam and electric requirements increase proportionately with the kill, the magnitude of the savings compared with the old plant is apparent.

TABLE II. OPERATING DATA FOR 140 DA. PERIOD FROM NOV. 26, 1932, TO APRIL 14, 1933

Steam produced (450 lb. pressure 650° T.T.)	131,417,400 lb.
Coal burned (heating value approx. 11,300 B.t.u.)	8,771 t.
Power generated	1,829,350 kw-hr.
Power generated by 1000 kw. non-condensing unit	1,807,950 kw-hr.
Power generated by 300 kw. condensing unit	21,400 kw-hr.
60 lb. steam used (Approximate—based upon 84 da. meter record)	81,000,000 lb.
Hours operation No. 1 (125 t. non-condensing) compressor	3,321 hr.
Hours operation No. 2 (250 t. condensing) compressor	3,357 hr.
Hours operation No. 3 (318 t. electric drive) compressor	1,077 hr.
Total Operating Expense (140 da. period)	$39,294.44

On a dollar basis a direct comparison by periods is not so easily made, principally because of changes in the price of coal; test periods after starting up the new plant and the fact that considerable unmetered steam was supplied this spring, for a well drilling rig. During the 165 da. period from Nov. 1, 1932, to April 14, 1933, the total operating cost was $45,671.99, made up of labor,

$8965.80; coal, $35,600.71, and oil, gas and miscellaneous, $1105.48. During the corresponding period of the previous year the total was $80,906.08, made up of labor, $7653.95; coal, $41,390.78; purchased power, $29,939.81; oil, gas and miscellaneous, $1921.54. This is a gross savings of $35,234.09 for the 165 da. period or a net savings of over $4000 after rental payments for the 5½ months are deducted. Savings due to lower maintenance and repair of the new equipment will not be available until the end of the year.

In rebuilding the plant, practically all the old equipment was retained either for active or standby service, the new high pressure plant being superimposed on the old so as to give a better utilization of the steam to supply the requirements of the packing plant. These requirements consist of electric power at 110, 220 and 440 v.; refrigeration (both direct expansion and brine) at temperatures of 20, 10 and minus 10 deg. F.; 150 lb. ga. steam for engines, pumps, etc.; 60 lb. ga. process steam; 3 lb. ga. steam for feedwater and space heating and for supplying hot water at 145 deg. F. Formerly electric power was purchased with two of the refrigeration compressors, pumps and auxiliaries driven by 150 lb. saturated steam supplied by three 400-hp. stoker fired boilers. Exhaust steam was used for building and water heating but the process steam at 80 lb. pressure (reduced to 60 lb. later with the slightly superheated steam from the new plant) was supplied through reducing valves from the 150 lb. line. Refrigeration compressors consisted of one 125-ton cross compound non-condensing unit, one 250-ton cross compound condensing unit and one 318-ton unit driven by a 450-hp. synchronous motor. Coal received by rail was fed from the track hopper by an apron conveyor to a Peck carrier which carried it under the engine room to the coal bunkers. Ash was elevated by the same carrier to a hopper at the back of the plant for delivery to trucks.

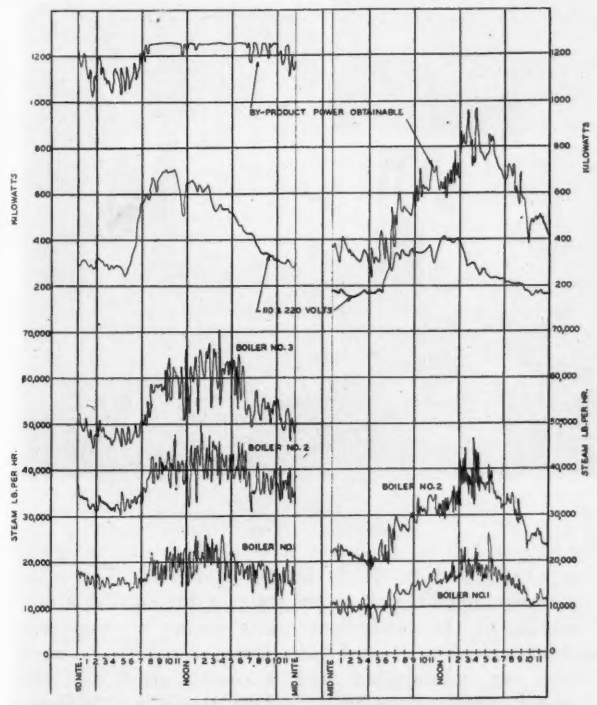


FIG. 5. STEAM AND ELECTRIC LOADS FOR TYPICAL HEAVY (LEFT) AND LIGHT (RIGHT) KILLING DAYS

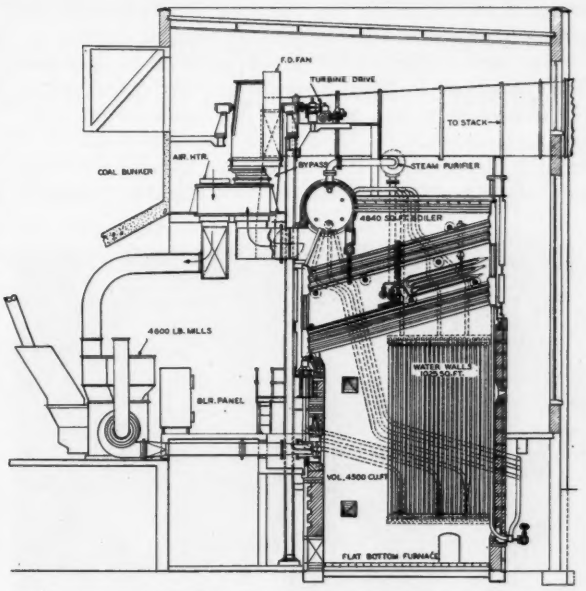


FIG. 6. TWO 484 HP., 450 LB. BOILERS WERE INSTALLED IN AN ADDITION TO THE BOILER ROOM

In the new plant the three 4000-sq. ft. 150-lb. boilers were kept for standby service and two new 450-lb. 650-deg. F., 4840-sq. ft. Springfield boilers were installed (in an addition to the boiler room) across the aisle so as to use the same coal and ash handling system. In the engine room two Elliott turbines were added on a balcony at one end of the room (in space formerly occupied by water treating equipment) as shown by Fig. 4. The large unit consists of a 1250-kva., 480-v., 3-ph., 60-cycle generator driven by a 425-lb., 625-deg. F. turbine bleeding up to 25,000 lb. of steam per hour at 150 lb. ga. to drive the steam driven compressors and auxiliaries, and exhausting at 60 lb. ga. for process work. The small unit consists of a 375-kva., 480-v., 3-ph., 60-cycle generator driven by a 150-lb. condensing turbine exhausting to a barometric condenser.

Equipment Details

Details of the boiler arrangement are shown by Fig. 6. They consist of 4840-sq. ft. Springfield boilers, with Elesco superheaters, 4000-sq. ft. Ljungstrom air heaters and 40,000-c.f.m. Buffalo induced draft fans driven by 150-lb. Elliott turbines. Furnaces partially water cooled by 1025 sq. ft. of bare water walls, have a volume of 4500 cu. ft. and a heat release of 19,750 B.t.u. per cu. ft. with boilers delivering 60,000 lb. of steam per hr. Furnace bottoms are flat and so arranged that ash can be raked directly into the conveyor.

Either pulverized coal or natural gas can be used, each boiler unit being supplied with a 4600-lb. motor driven Unipulvo, a third pulverizer of the same size being installed as shown by Fig. 4 so that it can be used with either furnace. This middle pulverizer has a dual drive, the steam turbine normally supplied with 150 lb. steam, is so designed and piped that it can be used on the accumulator system and will pull the full pulverizer load with a steam pressure as low as 60 lb. ga. Both boilers are served by a new 167 ft. reinforced concrete stack with an internal diameter of 6 ft. 6 in. at the top, with the breeching arranged so that at loads of or

below 35,000 lb. steam per hour the induced draft fan can be bypassed so as to operate on natural draft.

The well water, which runs around 27 gr. per gal. total hardness, is treated for boiler feed purposes in Cochrane hot process heater, as the makeup, although lower than the 80 per cent in the old plant, still runs around 70 per cent. Hagan auxiliary phosphate treatment, Cochrane steam purifiers, and Cochrane continuous blow-down are also used, the blow-down flashing to the feedwater heater and then flowing to the general plant hotwell so that all the heat is recovered. Boiler feed pumps are in duplicate, 200-g.p.m., 1175-ft. head, 3500-r.p.m. De Laval centrifugals, one driven by 100-hp. Elliott turbine with Fisher governor, the other by a 100-hp. Westinghouse motor with a Copes pressure regulator.

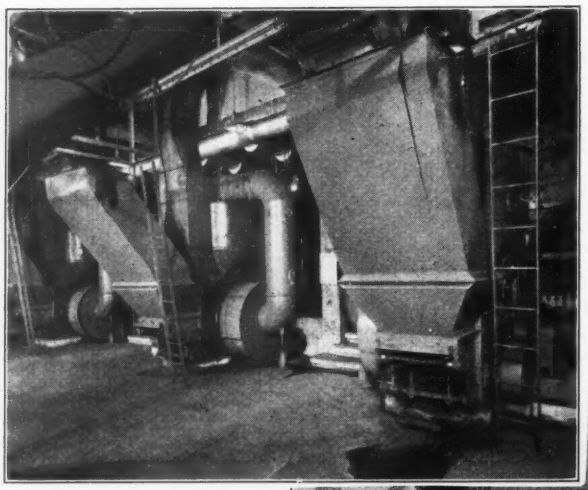


Fig. 7. (Above) Three 4600 lb. Pulverizers Are Used, the Middle One Firing Either Furnace Is Dual Driven. Fig. 8. (Right) Looking from the Turbine Gallery Toward the Three Refrigeration Compressors on the Main Floor

Flexibility in Operation

Flexibility in operation is built into the plant largely through dual driven or duplicate auxiliaries while short peaks are smoothed out by a 11,000 cu. ft. Ruths accumulator, the first vertical unit in this country, the vertical design being preferred because of space limitations. The accumulator, working between 155 and 60 lb. pressure, has reduced the peak load on the boilers by about 15,000 lb. of steam per hr. The 60-hp. dual drive on one of the pulverizers, the 100-hp. duplicate boiler feed, the 450-hp. ammonia compressor motor and a 40-hp. air compressor motor gives a total of 650 hp., or 485 kw., which can be changed from steam to electric power in practically any desired combination to give the necessary steam and power balance. With the 450-hp. synchronous compressor motor operating the power factor is high and the total generating capacity of the two turbines under these conditions could be boosted to somewhat over 1500 kw., if necessary.

Condenser Loss

Even the usual condenser loss is eliminated as heat in the exhaust steam to the condensers is recovered by the condensing water, which is stored in a hotwell to be used in the hot water system throughout the plant. This water comes originally from wells about 1250 ft. deep at a constant yearly temperature of about 50 deg. F. From the wells it is stored in a 650,000 gal. reservoir under the machine shop and then pumped to two elevated tanks. From these tanks it flows by gravity over the ammonia condensers to the hotwell. If the steam condensers (barometric type) are in operation, water leaving the ammonia condensers flows through the steam condensers and then to the hotwell, thus recovering all the heat. From the hotwell the water is picked up and pumped through a closed heater where it is heated to 145 deg. F. for use around the plant, this heating being done in a Bros 260 sq. ft. closed heater which drains to the condensate section of the feedwater heater. The plant uses some 450,000 gal. of hot water a day so that a normal use of the condensing units means no heat loss. Under emergency conditions steam condenser cooling water can be supplied from a nearby creek and this being returned downstream entails the usual condenser loss.

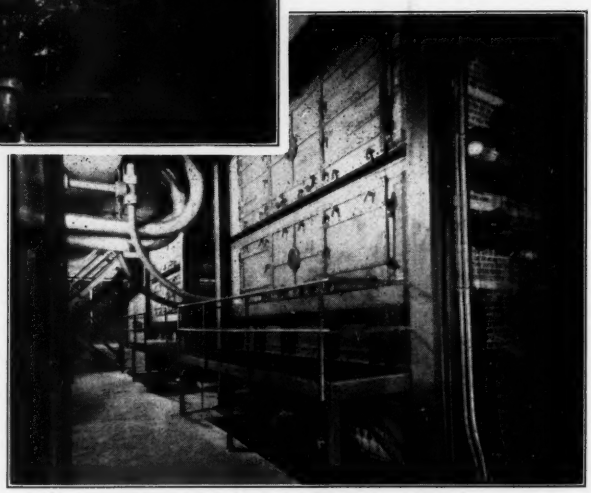


Fig. 9. (Below) View of the Boiler Fronts Showing the Two Combination Coal and Gas Burners. The older boilers across the aisle are stoker fired and are being kept for standby service. They are not to be changed for natural gas firing

Principal Equipment for Jacob E. Decker & Sons Plant

GENERAL

Service..Heat and power for packing plant
Location.....Mason City, Iowa
Lessee and Operator.....Jacob E. Decker & Sons
Lessor.....Power Service Corporation
Engineers...Ralph D. Thomas & Associates
General Contractor.....Fegles Construction Co., Ltd.

BOILERS AND AUXILIARIES

Boilers—Springfield Boiler Co., 2, 4840 sq. ft., 450 lb. ga., straight tube boilers with 1025 sq. ft. of bare water walls. Furnace volume 4500 cu. ft. Heat release at maximum continuous steaming rate of 60,000 lb. per hr., 19,750 B.t.u. per cu. ft.

Superheaters—Superheater Co., designed for total steam temperature of 650 deg. F. at 40,000 lb. per hour.

Air Heaters—Air Preheater Corp., 2, Ljungstrom heaters 4000 sq. ft. with rotating elements driven by Westinghouse 2 hp. 440 v., 1160 r.p.m. motor through a W. A. Jones Fdry. & Machine Co. 16½ to 1 speed reducer.

Induced Draft Fan—Buffalo Forge Co., 2, No. 8 D. H. G. S., capacity 45,600 c.f.m., at 4 in. of water. Each driven by an Elliott 50 hp., 150 lb., 70 deg. superheat, 4990 r.p.m. non-condensing geared turbine.

Pulverizers—Strong Scott Mfg. Co., 3, 4600 lb. Unipulvos. Two pulverizers driven by 60 hp., 440 v. Westinghouse induction motors, the third pulverizer (which serves either boiler) dual driven by a 60 hp., 440 v. Westinghouse motor and a 60 hp. Elliott non-condensing turbine designed for steam pressures from 150 lb. ga. to as low as 60 lb. ga.

Boiler Feed Pumps—De Laval Steam Turbine Co., 2, 200 g.p.m., 1175 ft. head centrifugals, one driven by a Westinghouse 100 hp., 440 v., 3520 r.p.m. induction motor, the other driven by an Elliott 100 hp. turbine, 150 lb. ga., 70 deg. superheat, non-condensing steam turbine.

Coal Scales—Richardson Scale Co., 3 automatic coal scales, one for each pulverizer.

Boiler Panels—Hays Corp., 2, boiler meter panels with Hays 4 pointer draft gages, Cochrane flow meter, Crosby steam gage, Permutit Co. Ranarex CO_2 recorders and Hays temperature recorders.

Chimney—General Concrete Const. Co., reinforced concrete 167 ft. high, diameter at top 6 ft. 6 in. I. D.

Combustion Control.....Hagan Corp.
Boiler Blowoff Valves.....Cochrane Corp.
Water Wall Drain Valves.....Edwards Valve & Mfg. Co.
Boiler Settings.....Michael Liptak
Breechings, Ducts & Boiler Platforms.....Bell & Eiss
Breeching Doors.....Wm. Bros Boiler & Mfg. Co.
Continuous Blowdown.....Cochrane Corp.
CO_2 Recorders..Ranarex, The Permutit Co.
Draft Gages.....Hays Corp.
Excess Pressure Regulators.....Fisher Governor Co., Northern Equipment Co.
Feed Water Regulators.....Copes, Northern Equipment Co.

Non-Return Valves and Check Valves.....Edwards Valve & Mfg. Co.
Pressure Gages.....Consolidated Ashcroft Hancock Co.
Pressure Recorders.....Cochrane Corp.
Safety Valves.....Crosby Steam Gage & Valve Co.
Soot Blowers.....Diamond Power Specialty Corp.
Stairway Grating...Irving Iron Works Co.
Steam Flow Meters (Boilers).....Cochrane Corp.
Steam Flow Meter (Process).....Bailey Meter Co.
Steam Purifiers.....Cochrane Corp.
Temperature Recorders.....Hays Corp.
Water Columns.Reliance Gauge Column Co.

TURBINES AND ELECTRICAL EQUIPMENT

Turbine—Elliott Co., 1, 1250 kv.a., 480 v., 3 ph., 60 cycle, 0.8 power factor 3600 r.p.m. generator driven by a 425 lb. ga. 625 deg. F., turbine designed to bleed at 150 lb. ga. and exhaust at 60 lb. ga.

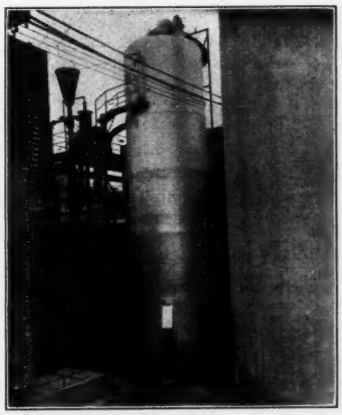
Generator Air Cooler—Griscom-Russell Co., 1, 306 sq. ft. of cooling area.

Turbine—Elliott Co., 1, 375 kv.a., 480 v., 3 ph., 60 cycle, 0.8 power factor, 3600 r.p.m. generator driven by a 150 lb. ga. ,70 deg. F. turbine exhausting at 27 in. to a barometric condenser.

Condenser—Elliott Co., 1, Barometric type.

Switchboard—Built by Commonwealth Electric Co. with Roller Smith Co., circuit breakers, Westinghouse Elec. & Mfg. Co. instruments, synchronizing panel and voltage regulator.

Transformers—Maloney Electric Co., 1, 1000 kv.a., 480/240 v. for power and 2, 75 kv.a. 480/120/240 v. for lighting.



STEAM ACCUMULATOR AND MISCELLANEOUS

Steam Accumulator—Ruths Steam Storage, Inc., 1, 11,600 lb., vertical steam accumulator and A.V.A. control valves. Accumulator 11 ft. in diameter, 45 ft. long with a volume of 4100 cu. ft. Designed for a working range of from 155 to 60 lb. ga.

Accumulator Feed Pump—West Co. Pump Co., 25 g.p.m., 190 lb. pressure, centrifugal pump motor driven.

Accumulator Insulation — Johns-Manville Corp.

Water Level Indicators—Schutte & Koerting Co., televisor on accumulator.

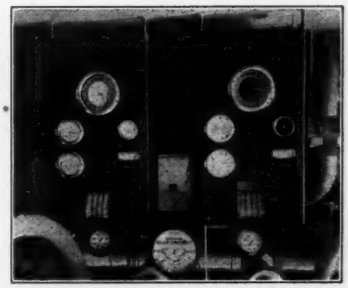
Water Softener—Cochrane Corp., type IJS, 10,000 g.p.h. hot process softener complete with vent condenser, chemical tank and proportioner, filter, pump and accessories.

Auxiliary Phosphate Treatment—Hagan Corp.

Closed Water Heater—Wm. Bros Boiler & Mfg. Co., 1, 250 sq. ft. closed heater, 34 in. in diameter, 14 ft. long with 2 in. brass tubes. Capacity 500 g.p.m. of water heated from 90 to 140 deg. F. Complete with separate hot-well.

Heater Drain Pumps—Buffalo Steam Pump Co., 2, single stage centrifugals, capacity 60 gal. against head of 60 ft. Driven by 2 hp., 220 v., 750 r.p.m. Westinghouse motors.

Exhaust Heads and Back Pressure Valves.....Cochrane Corp.
Piping.....Crane Co.
Piping Installed by....A. R. Robertson Co.
Pipe Covering.....Johns-Manville
G. A. MacArthur Co.
Turbine Atmos. Relief.....Edwards Valve & Mfg. Co.
Valves.....Crane Co.
Edwards Valve & Mfg. Co.
Northern Equipment Co.
The McAlear Mfg. Co.



EQUIPMENT FROM ORIGINAL PLANT

Ammonia Compressor—Vilter Mfg. Co., 1, 312 t., 16½ by 32 in. ammonia compressor, driven by an Ideal 450 hp. unity power factor, 80 r.p.m. 440 v. synchronous motor complete with Allen Bradley starting panel and 15 kw., 750 r.p.m., 125 v. Ideal exciter driven by a 440 v., 22 hp. motor.

Ammonia Compressor—Vilter Mfg. Co., 250 t., 17 by 34 in. horizontal duplex ammonia compressor, driven by a 20 and 40 by 34 in. condensing Corliss engine, exhausting at 24 in. to a barometric condenser.

Ammonia Compressor—Vilter Mfg. Co., 1, 125 t., 13 by 26 in. horizontal duplex ammonia compressor, driven by an 18 and 32 by 26 in. cross compound non-condensing Corliss engine.

Barometric Condenser—Vilter Mfg. Co.
Condenser Air Pumps—Vilter Mfg. Co.
Boilers—Murray Iron Works, 3, 4000 sq. ft., water tube boilers.
Stokers—Combustion Engineering Corp. Type E stokers.
Pump Out Compressor—Continental Machine Co., 6 by 6 in., 2 cylinder vertical compressor, rated 10 t. at 250 r.p.m. Belted to a 25 hp. 220 v. General Electric motor.
Boiler Feed Pumps—Gardner-Denver Co., 2, 12 by 8 by 12 in. horizontal duplex steam pumps with Fisher governor. Standby boiler feed pumps for 150 lb. boilers.
Deepwell Pump—Pomona Pump Co., vertical centrifugal with capacity of 450 g.p.m., driven by a 75 hp., 220 v., Westinghouse motor.
General Service Pumps—Gardner-Denver Co., 1, 16 by 12 by 12 in. horizontal duplex steam pump and 1, 12 by 8 by 12 in. horizontal duplex steam pump.
Cooling Water Pumps—Ingersoll Rand Co., 1, 350 g.p.m., 45 lb. pressure centrifugal, driven by a Westinghouse 15 hp. motor and 1, 850 g.p.m., 45 lb. pressure, centrifugal pump, driven by a 25 hp. Westinghouse motor.
Condenser Water Pump—Fairbanks, Morse Co., 1, 600 g.p.m., 45 lb. pressure, centrifugal pump driven by 20 hp. motor. This pump can take its suction from the reservoir or in an emergency from the creek to supply water to the steam condensers.
Sump Pump—American Well Works, 1, size 2, vertical, driven by a 2 hp., 220 v., 1750 r.p.m. Century motor with a General Electric float control switch.
Air Compressor—Ingersoll Rand Co., 1, 10 by 10 in., driven by close belt drive by a Westinghouse 40 hp., 220 v., 1100 r.p.m. motor.
Air Compressor—Ingersoll Rand Co., 1, 12¼ and 18¼ by 12 in., 2 stage air compressor, driven by a 13 and 20 by 12 in. cross compound steam engine.
Ammonia Storage Tank—Vilter Mfg. Co., 8 ft., diameter, 36 ft. long.
Ammonia Condensers and Receiver.....Vilter Mfg. Co.
Air Receiver.....Murray Iron Works Co.
Coal Conveyor.....Link-Belt Co.
Pressure Gages....Crosby Steam Gage Co.
Bristol Co.
U. S. Gage Co.
Thermometers.....Taylor Instrument Co.
Traps.....W. H. Nicholson & Co.
Crane Co.

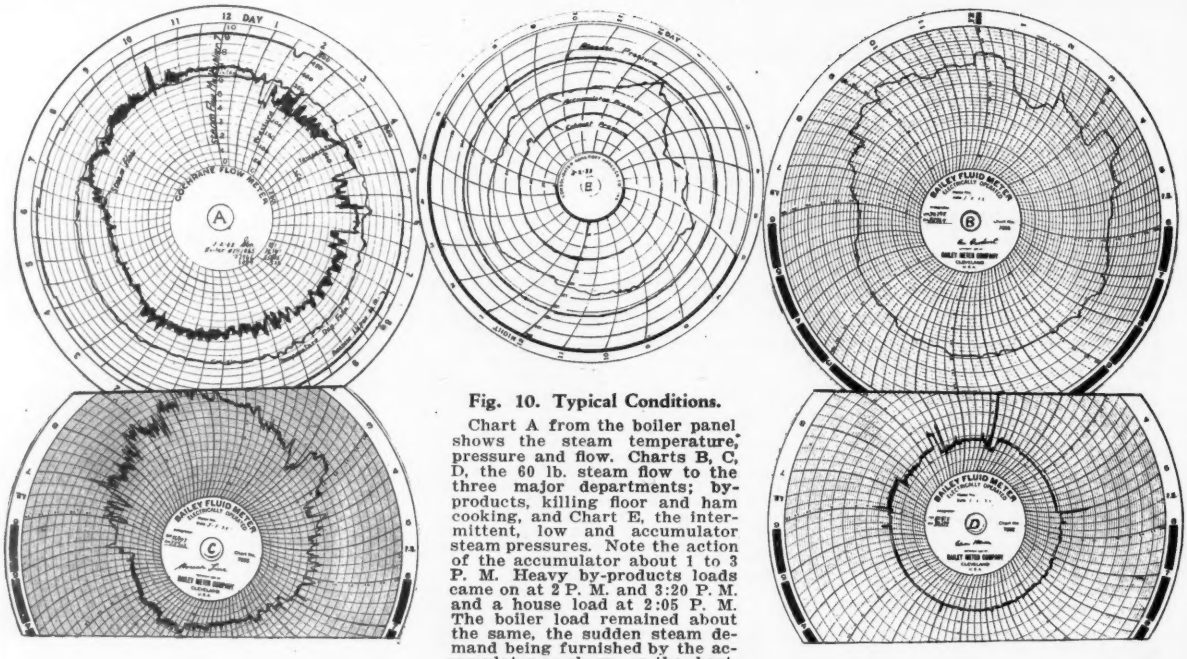


Fig. 10. Typical Conditions.

Chart A from the boiler panel shows the steam temperature, pressure and flow. Charts B, C, D, the 60 lb. steam flow to the three major departments; by-products, killing floor and ham cooking, and Chart E, the intermittent, low and accumulator steam pressures. Note the action of the accumulator about 1 to 3 P. M. Heavy by-products loads came on at 2 P. M. and 3:20 P. M. and a house load at 2:05 P. M. The boiler load remained about the same, the sudden steam demand being furnished by the accumulator as shown on the chart.

Typical steam and electric loads on the old plant during periods of heavy and light killing are shown by Fig. 5. The left hand chart shows a January day with a kill of about 4200 hogs, the right hand side a June day with a lighter kill of about 2200. In the former the maximum steam demand is approximately 70,000 lb. per hour and the maximum power demand of about 750 kw. which in the latter is reduced to 35,000 lb. per hr. and 410 kw. respectively. Neither electric load includes the 450-hp. refrigeration machine motor which was operated from an individual 440 v. line. A heat balance for the old plant for average conditions is shown by Fig. 3. Of the total of about 35,000 lb. of steam per hr., over a third was used for engines and pumps while the balance was reduced to 80 lb. ga. and used largely for cooking and heating. A small portion of the condensate was recovered and the makeup ran well over 80 per cent.

A flow diagram of the new plant is shown by Fig. 1. Normally steam at 450 lb., 650 deg. F. from the new boilers flows to the large turbine and also charges the accumulator through the AVA valve 1. Steam bled at 150 lb. ga. is used to operate the induced draft fan turbines, the turbine driven boiler feed pump and the steam driven ammonia compressors, the 3 lb. exhaust from these units being used for building and water heating. Exhaust through a reducing valve for maintaining pressure in the 3 lb. system, the 60 lb. pressure being maintained constant regardless of turbine load by the accumulator through AVA valve 3. If the intermediate system pressure exceeds 155 lb. steam spills through the AVA valve 2 to the accumulator system. Pressure in the 150-lb. system is controlled automatically by the bleeder mechanism which is of the speed compensated type, interconnected with the speed governor and steam admission valves. This interconnection provides accurate frequency control, makes possible parallel operation and prevents bleeding the turbine beyond the limits of the design which would, of course, result in the failure of the turbine to carry its electrical load. Consumption of 150 lb. steam can be controlled within limits by shifting from motor to steam drive on the auxiliaries or by operating the condensing ammonia compressor. Further control is possible by means of the 375 kv.a. condensing turbo-generator which is normally used as a load balancing unit. Actually, the loads are so well balanced that this turbine is seldom needed and was not operated during March and April.

Opportunity for Interchange Agreement

Although the primary function of the 375 kv.a. turbo-generator is to take care of exceptional power demands when the killing is irregular at certain periods of the year, it is also used for the Sunday and holiday electric load or in an emergency to carry the essential power load. The shut down of the single large turbo-generator would not cripple essential services for steam can be supplied through a reducing valve to the 150 lb. system and operate the steam compressors, auxiliaries and the 375 kv.a. turbo-generator for power generation. Even the loss of both high pressure boilers would not shut the plant down as the old boilers are still in good operating condition and could supply the necessary 150 lb. steam to the compressors, auxiliaries and 375 kv.a. turbo-generator. The single large generating unit is a temporary condition as additional electric load, to be added by the beef kill now under construction, will necessitate another generating unit, the details of which will be determined as soon as the requirements are definitely known. Space is already provided in the turbine room for this machine. This offers an excellent opportunity for a power interchange agreement with the utility company, a feature of industrial power which has been used to some extent in different parts of the country and which, not wholly in accord with utility policy as a whole, will undoubtedly play an important part in future industrial power expansion.

Part II. Calculation of Friction Loss in Tubes and Water Boxes of Extraction Heaters. Part I, showing the method of calculating surface tube length and number of passes appeared on page 200 of the May 1933 issue of Power Plant Engineering.

CLOSED FEEDWATER HEATER DESIGN

By
FRANK R. WHEELER

FOLLOWING CALCULATION of surface tube size, length and number of passes to meet specific conditions and comply with physical limitations, it is necessary to know the friction loss on the water side.

Water is delivered at the inlet flange of the heater at some definite velocity part of which is almost immediately dissipated in eddies and friction, due to reduction in velocity because of increased area of the water box as compared with the inlet pipe. This lost velocity should be recreated at the outlet flange, but since it is controlled by the station piping rather than the heater design and seldom exceeds 10 in. water, it will not be considered in this discussion.

Total resistance to flow through the heater itself consists of the resistance due to water box passages and entry and exit losses of the tubes plus the resistance to flow in the tubes.

The pressure loss expressed in feet head at the tube entrance at each pass is that required to produce the velocity in the tubes or $sV^2 \div 2g$, where $g = 32.16$ and s = specific gravity of the water referred to water at 39.2 deg. F. This must be increased due to contraction losses at the entrance to the tubes. Taking the coefficient of contraction as 0.62, the entrance loss would amount to $(1 - 0.62)\ sV^2/2g$. Making the total entrance and exit loss for each pass $1.38\ sV^2/2g = 0.02145\ sV^2$. In actual practice, the close proximity of the tube and projecting ferrules, or tube ends, would increase the constant to some value between 0.0233 and 0.0310 which includes the loss due to eddies and wall friction of the water boxes. Based on such published and private test data as is available, we find that the entry, exit and waterbox losses may be expressed as $0.03\ sV^2n$.

The generally accepted value for loss through small tubes is given by the well known Fanning formula which simplified for turbulent flow, as is always used in extraction work, increased by a tube cleanliness factor of 20 per cent and added to the above waterbox losses gives an expression which for practical purposes can be simplified to

$$H = (L + 6.5d^{1.25})\ p\ n \div d^{1.25} \qquad (6)$$

where

$$p = 0.0075\ s^{0.75}\ V^{1.75}\ z^{0.25} \qquad (7)$$

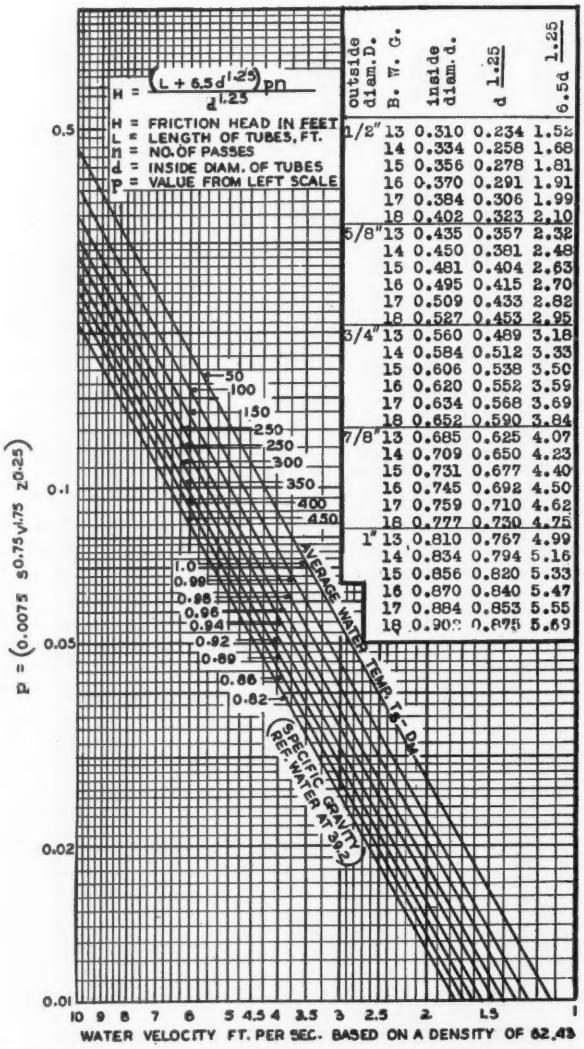
This latter, Eq. 7, has been plotted as a chart, Fig. 4, for various values of velocity and temperature. To facilitate the solution of Eq. 6 the chart also shows a table of values D, d, $d^{1.25}$ and $6.5d^{1.25}$ for tube sizes ranging from ½ to 1 in.

The value of p is a function of velocity and also of viscosity and density, which in turn are functions of temperature. The temperature used should be the mean of the inlet and outlet water temperatures, which is best represented by the difference between the steam temperature and mean temperature difference or $(T_s—D_m)$.

TABLE III. STANDARD TUBE DATA. THE CONSTANT C EQUALS POUNDS OF WATER PER HOUR PER TUBE DIVIDED BY VELOCITY IN FEET PER SECOND AND IS EQUAL TO $1223d^2$.

Outside Diameter	B.W.G.	Inside Diameter	Weight		Surface Outside Sq. Ft.		Inside Surface per ft. length	Sectional area sq. inches		Velocity per 1 G.p.m.	G.p.m. per 1 ft. vel.	Constant C
			Per foot	Per 100 sq. ft.	Per foot	Per inch		Outside	Inside			
1/2	10	0.232	0.5674	433.4	0.1309	0.0109	0.0608	0.1963	0.04 4	7.56	0.1321	65.9
	11	0.260	0.5280	403.3	0.1309	0.0109	0.0682	0.1963	0.0532	6.03	0.1657	83.8
	12	0.282	0.4908	375.0	0.1309	0.0109	0.0748	0.1963	0.0633	5.06	0.1972	97.3
	13	0.310	0.4454	340.2	0.1309	0.0109	0.0812	0.1963	0.0755	4.25	0.2351	117.8
	14	0.334	0.4010	306.2	0.1309	0.0109	0.0874	0.1963	0.0876	3.662	0.2730	136.7
	15	0.356	0.3626	276.9	0.1309	0.0109	0.0917	0.1963	0.0980	3.272	0.3052	155.2
	16	0.370	0.3276	250.1	0.1309	0.0109	0.0969	0.1963	0.1076	2.980	0.3352	167.5
	17	0.384	0.2978	227.3	0.1309	0.0109	0.1005	0.1963	0.1157	2.772	0.3605	180.6
	18	0.402	0.2582	197.2	0.1309	0.0109	0.1052	0.1963	0.1269	2.530	0.3955	197.8
	20	0.430	0.1888	144.3	0.1309	0.0109	0.1125	0.1963	0.1452	2.209	0.4525	226.5
5/8	10	0.357	0.700	464.2	0.16362	0.01364	0.0937	0.3068	0.100	3.224	0.3102	155.0
	11	0.385	0.700	428.0	0.16362	0.01364	0.1010	0.3068	0.117	2.730	0.3660	182.0
	12	0.407	0.649	396.0	0.16362	0.01364	0.1070	0.3068	0.130	2.474	0.4040	202.0
	13	0.435	0.581	365.0	0.16362	0.01364	0.1142	0.3068	0.149	2.154	0.464	232.0
	14	0.459	0.520	317.6	0.16362	0.01364	0.1205	0.3068	0.165	1.984	0.504	252.0
	15	0.481	0.460	281.0	0.16362	0.01364	0.1260	0.3068	0.1817	1.766	0.566	283.0
	16	0.495	0.421	256.7	0.16362	0.01364	0.1299	0.3068	0.1925	1.663	0.601	300.0
	17	0.509	0.380	232.2	0.16362	0.01364	0.1331	0.3068	0.2035	1.579	0.635	317.0
	18	0.527	0.326	199.5	0.16362	0.01364	0.1382	0.3068	0.2181	1.472	0.680	340.0
	20	0.541	0.238	145.5	0.16362	0.01364	0.1455	0.3068	0.242	1.328	0.754	377.0
3/4	10	0.482	0.950	434.0	0.19635	0.01637	0.1265	0.4418	0.1822	1.760	0.568	284.0
	11	0.510	0.870	443.2	0.19635	0.01637	0.1335	0.4418	0.2043	1.566	0.648	319.0
	12	0.532	0.807	411.0	0.19635	0.01637	0.1400	0.4418	0.223	1.441	0.694	347.0
	13	0.560	0.718	365.8	0.19635	0.01637	0.1470	0.4418	0.247	1.302	0.766	384.0
	14	0.584	0.640	326.0	0.19635	0.01637	0.1530	0.4418	0.268	1.202	0.832	416.0
	15	0.606	0.563	287.0	0.19635	0.01637	0.1590	0.4418	0.289	1.111	0.900	450.0
	16	0.620	0.514	262.0	0.19635	0.01637	0.1627	0.4418	0.3019	1.069	0.936	470.0
	17	0.634	0.464	236.1	0.19635	0.01637	0.1660	0.4418	0.3057	1.019	0.983	490.0
	18	0.652	0.396	202.0	0.19635	0.01637	0.1706	0.4418	0.3339	0.962	1.040	520.0
	20	0.680	0.259	147.0	0.19635	0.01637	0.1780	0.4418	0.3632	0.883	1.133	567.0
7/8	10	0.602	1.153	503.0	0.2291	0.01909	0.158	0.6014	0.288	1.114	0.898	449.0
	11	0.635	1.046	456.0	0.2291	0.01909	0.167	0.6014	0.317	1.012	0.988	494.0
	12	0.657	0.984	429.0	0.2291	0.01909	0.172	0.6014	0.334	0.960	1.042	521.0
	13	0.685	0.862	376.0	0.2291	0.01909	0.1795	0.6014	0.367	0.874	1.144	572.0
	14	0.709	0.763	333.0	0.2291	0.01909	0.186	0.6014	0.394	0.815	1.227	614.0
	15	0.731	0.630	275.2	0.2291	0.01909	0.1915	0.6014	0.420	0.762	1.312	656.0
	16	0.745	0.609	266.0	0.2291	0.01909	0.1951	0.6014	0.4360	0.736	1.360	678.0
	17	0.759	0.548	239.0	0.2291	0.01909	0.1988	0.6014	0.4524	0.710	1.410	702.0
	18	0.777	0.466	204.5	0.2291	0.01909	0.2034	0.6014	0.4742	0.676	1.479	740.0
	20	0.805	0.340	148.4	0.2291	0.01909	0.2107	0.6014	0.5090	0.631	1.585	790.0
1	10	0.732	1.54	512.0	0.2618	0.02179	0.192	0.7854	0.421	0.784	1.31	655.0
	11	0.760	1.22	466.0	0.2618	0.02179	0.200	0.7854	0.455	0.706	1.416	708.0
	12	0.782	1.12	428.0	0.2618	0.02179	0.205	0.7854	0.479	0.671	1.490	745.0
	13	0.810	0.99	378.0	0.2618	0.02179	0.213	0.7854	0.515	0.625	1.60	800.0
	14	0.834	0.88	336.0	0.2618	0.02179	0.2183	0.7854	0.5463	0.586	1.70	850.0
	15	0.856	0.77	294.2	0.2618	0.02179	0.225	0.7854	0.576	0.556	1.793	896.0
	16	0.870	0.700	266.0	0.2618	0.02179	0.2277	0.7854	0.5948	0.540	1.850	928.0
	17	0.884	0.632	241.7	0.2618	0.02179	0.2314	0.7854	0.6138	0.524	1.910	958.0
	18	0.902	0.540	206.0	0.2618	0.02179	0.2362	0.7854	0.6410	0.503	2.000	1000.0
	20	0.930	0.389	149.0	0.2618	0.02179	0.2435	0.7854	0.6793	0.474	2.120	1055.0

Referring again to the problem set up in the first part of this article in the May issue in which the water velocity was 6 ft. per sec., and the tubes 5/8 in., No. 16 B.w.g. 15.6 ft. long, arranged for three passes of the water through the heater; the mean water temperature is 212 —36.78 = 175.22 deg. F. and the specific gravity (referred to water at 39.2 deg. F.) from Fig. 4 is 0.97. The velocity at the bottom of the chart, Fig. 4, is based on water at 39.2 deg. F. and for higher temperatures must be corrected by dividing by the specific gravity. Thus the corrected velocity in this example


H = (L + 6.5d^1.25)pn / d^1.25
H = FRICTION HEAD IN FEET
L = LENGTH OF TUBES, FT.
n = NO. OF PASSES
d = INSIDE DIAM. OF TUBES
p = VALUE FROM LEFT SCALE
p = (0.0075 s^0.75 v^1.75 z^0.25)
WATER VELOCITY FT. PER SEC. BASED ON A DENSITY OF 62.43
AVERAGE WATER TEMP. T = Deg.
(SPECIFIC GRAVITY REF. WATER AT 39.2)

outside diam. D.	B. W. G.	inside diam. d.	d 1.25	6.5d 1.25
1/2"	13	0.310	0.234	1.52
	14	0.334	0.258	1.68
	15	0.356	0.278	1.81
	16	0.370	0.291	1.91
	17	0.384	0.306	1.99
	18	0.402	0.323	2.10
5/8"	13	0.435	0.357	2.32
	14	0.450	0.381	2.48
	15	0.481	0.404	2.63
	16	0.495	0.415	2.70
	17	0.509	0.433	2.82
	18	0.527	0.453	2.95
3/4"	13	0.560	0.489	3.18
	14	0.584	0.512	3.33
	15	0.606	0.538	3.50
	16	0.620	0.552	3.59
	17	0.634	0.568	3.69
	18	0.652	0.590	3.84
7/8"	13	0.685	0.625	4.07
	14	0.709	0.650	4.23
	15	0.731	0.677	4.40
	16	0.745	0.692	4.50
	17	0.759	0.710	4.62
	18	0.777	0.730	4.75
1"	13	0.810	0.767	4.99
	14	0.834	0.794	5.16
	15	0.856	0.820	5.33
	16	0.870	0.840	5.47
	17	0.884	0.853	5.55
	18	0.902	0.875	5.69

FIG. 4. CHART FOR SOLVING EQ. 7 IN ORDER TO DETERMINE THE FRICTION LOSS ON THE WATER SIDE OF THE HEATER

is 6 ÷ 0.97 = 6.19. Enter the chart Fig. 4 at the bottom at a corrected velocity of 6.19, pass vertically to a point midway between the 150 and 200 deg. F. temperature lines, then horizontally to the side of the chart, we find p = 0.1375. From the table on the chart we find $d^{1.25} = 0.415$ and $6.5d^{1.25} = 2.70$. Substituting these values in Eq. 6 we have,

H = (15.60 + 2.70) x 0.1375 x 3 ÷ 0.415 = 18.2 ft.

This is equivalent to 7.88 lb. per sq. in., or well within the 10 lb. pressure loss limit imposed. Selecting a higher velocity than 6, as assumed, would reduce the surface and increase the friction head.

As a matter of interest, the friction head of the heater with 3/4 in., No. 15 B.w.g. tubes, 14.55 ft. long and arranged for four passes would be 20.5 ft., or 8.78 lb.

It is important in computing heater heads for plant design to use the coldest water temperature that is likely to be pumped through the heater system. For example, with an average water temperature of 100 deg. F., the friction in the heater with 5/8 in. tubes would be increased from 18.2 to 20.87 ft., which is equal to 9.04 lb.

Hoover Dam Model at "Century of Progress"

AN EXACT MODEL OF THE Hoover Dam and Power Plant, the biggest thing of its kind ever built by man, will be seen by millions of people who visit the Chicago Century of Progress Exposition this summer. The Bureau of Reclamation, in the Department of the Interior, which is responsible for the execution of the vast project which is being worked out in the lower end of the thousand-mile stretch of canyon through which the Colorado River takes its lonesome and turbulent course.

The model was built at the Denver Office of the Reclamation Service under the direction of Chief Engineer R. F. Walter. It is 17 ft. long and 12 ft. in height and is so installed that the spectator has the same view as if he were standing on the rim of the canyon walls and looking down into the gorge 1200 ft. below. Above the canyon the model merges into a painted background, semicircular in shape, which gives a realistic idea of the rugged, precipitous mountains and the lonesome walls of the gorge through which are river has flowed for unnumbered centuries, and of the adjoining desert of Nevada and Arizona.

It was built on a scale of one inch to 30 ft. both horizontal and vertical. All features of the dam are accurately represented. The reservoir is filled with water so that the power plant, outlet works and discharge through the spillways can be operated in miniature, just as they will be worked after the dam has been constructed. The model serves to show to those who cannot visit Boulder City, the construction town where 7000 people now live, the magnificent scenery and the tremendous conquest of nature which the engineers and contractors are now carrying on.

THE VOLTAGE ON the secondary terminals of a transformer produced by the impact of a lighting wave on the primary side consists of four components, three of which depend on the relative position and distribution of windings and of the core and the fourth, the electromagnetic, only upon the short circuit reactances of the transformer and is the same for transformer having the same reactance in henries and the same turn ratio, no matter how different may be the design features.

NEWLY DISCOVERED deposits of radium ore in Canada render it probable that we shall no longer depend on the Belgian Congo for that rare and expensive material. Already tons of ore have been brought out by airplane.—Chemical Digest.

Boiler Corrosion Investigation in Germany

Various investigations and tests show causes of boiler corrosion to be diverse in nature. Tests on glass models indicate the conditions could be remedied by control of water velocity through tubes.

AT A MEETING of the German Association of Boiler Owners in Dresden, feedwater treatment received a prominent place. One of the engineers, making a report of experience gained at the Government Material Testing Bureau from investigating failures of boilers on pressures of up to 500 lb. per sq. in., felt that the material should receive more attention. Corrosion is of secondary importance, in his estimation. Cause of failure can be found under four headings: material itself; defective methods of manufacture and physical properties; defects occasioned by construction and operation; type of welding.

Even the best material can be spoiled by wrong treatment. Attention was called to the harmful effect of cold bending and working; excessive riveting pressure with the crushing of the material around the hole; the drifting of rivet holes; excessive work in expanding tubes. Apart from failures due to corrosion, failures of operation are caused largely by defective circulation causing local overheating or by excessive stiffness in construction. In some cases reinforcing plates were shown to have been a source of weakness rather than strength. Welding of cracks is stated to be worthless and dangerous because repairs of this kind do not remove the fundamental cause of the cracks.

Corrosion

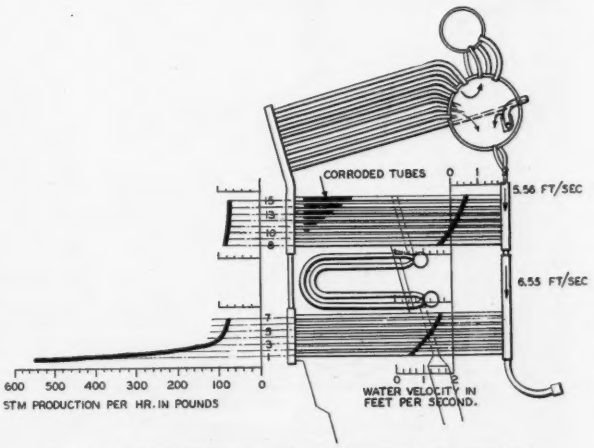
An interesting case of corrosion at the Merseburg Ammonia Works where six 650 lb., 10,760 sq. ft. boilers are installed was discussed. Three of these boilers have vertical tubes and three have inclined tubes. After the plant had been in operation a year, two tubes in the first row of one of the vertical boilers began to leak. Phosphate treatment was adopted and no further signs of corrosion occurred.

Later in the inclined tube boilers corrosion occurred at the upper ends of the top rows in the top bank of tubes, as shown in the drawing. Corroded portions were greatest in the top row and decreased downward as indicated. Inspection showed that the other two inclined boilers were affected in the same way while the vertical boiler was now free from corrosion. This eliminated the possibility of trouble in the phosphate feed and it was decided that trouble arose from trapping of steam in these particular rows.

Careful investigation showed that the velocity changed from 0.65 ft. per sec. upward (in the bottom tubes of this bank) to about the same velocity downward (in the top tubes). Evaporation rates showed that steam was produced in these top rows which indicates that even under these adverse conditions cooling was adequate.

Tests carried out with glass models using air and steam showed that the downward flow of water tended to check the flow of steam causing the latter to pocket in the upper end of the tube. Insertion of sheet metal dividing walls to separate the water and steam was tried in an effort to remedy the condition, although the most effective method of control was found to be limitation of the velocity of the water by inserting plugs with small holes in the bottom ends of all the tubes of the top bank.

Corrosion in these two types of boilers offers an interesting study. During the first year of operation when these tubes were protected by a light coating of scale a direct contact of steam and metal was prevented and


CORRODED TUBES
5.56 FT/SEC
6.55 FT/SEC
600 500 400 300 200 100 0
STM PRODUCTION PER HR. IN POUNDS
WATER VELOCITY IN FEET PER SECOND.

STEAM PRODUCTION AND VELOCITIES IN GERMAN BOILER

no trouble arose. After the phosphate treatment this scale was removed, protection of the scale was absent and dissociation of steam took place causing the corrosion.

Plugs Not Tight

After a few months' operation traces of corrosion were found in spite of the plugs. It was found that the plugs, 0.315 in. in diameter did not fit tightly in the tubes. Leakage of water increased the velocity sufficiently to trap the steam and start corrosion. After the plugs were made tight no more corrosion was observed over a period of ten months.

Discussion brought out the fact that plugging the tubes of the upper bank did not materially affect circulation in the lower bank. The fundamental requirement for boiler circulation is that the strongly heated tubes should have a definite upward circulation while tubes in which the water flows downward should not be heated or should be heated very slightly so that they in effect form an economizer rather than a boiler section.

THE LARGEST incandescent lamp is rated at 50,000 watts—50 kilowatts! The filament for such a lamp is a coiled rod of tungsten weighing 3 lb.—enough tungsten to make filaments for more than 125,000 lamps of 25 watt rating. The operating temperature of the filament is about 5650 deg. F. and the lamp operating at 120 v. produces about 1,500,000 lumens.

Electric Power and Light *for A Century of Progress*

SIGNIFICANT OF THE progress made in the application of electric light and power in forty years is the fact that a single building at the Century of Progress Exposition uses more electricity than did the entire World's Columbian Exposition in Chicago in 1893. Forty years ago, electricity was still a novelty, yet it *made* the World's Columbian Exposition for this was the first World's Fair to be lighted by electricity.

Today, electricity is the very life blood of the Century of Progress Exposition—without electricity this fair would not be possible. From the very instant that it announces one's entrance into the exposition grounds by contacts on the turnstiles until one leaves late at night under the splendor of an artificial aurora borealis created by a battery of electric searchlights electricity is at work, in countless ways.

The layman is interested in the effects produced at the fair by the application of electricity, but the engineer in addition to the effects is interested in knowing something about the system which makes the effects possible. It is naturally somewhat of an unusual undertaking to install an electric transmission and distribution system of 36,000 kw. which is to have an operating life of only five months and as a consequence the electrical system at the fair presents many unusual features. With the one exception of requirements for safety, no regard for precedent or previous practice was permitted to interfere with the development of a thoroughly reliable yet inexpensive system. For this reason, the electrical installation is characterized by many strange things which have never been done before. Many of the practices would outrage the principles and professional ethics of hidebound engineers not susceptible to the assimilation of new ideas.

All electricity used at the exposition is purchased from the Commonwealth Edison Co., this company having an investment of some $176,000 in conduits, cables and substation equipment at the grounds. The greater part of the exposition area is served from a substation in the Soldier's Field stadium structure to which two 12,000-v. cables are run from the Edison system. An additional point of supply is from the 39th Street substation of the company.

As may be seen upon the accompanying diagram, 9 cables lead from the Soldier's Field substation to the exposition grounds. These are 4000-v., three-wire Y feeders and are carried underground to the transformer vaults in the various buildings. A tenth, 4000-v. feeder extends from the 39th Street substation to the Travel and Transport Group and the exhibits at the north end of the fair. The Soldier's Field substation contains six 12,000/4000-v. transformers with a total rated capacity of 30,000 kv-a.

In order to keep the costs low conventional methods of cable laying were abandoned and all equipment in the transformer vaults and elsewhere was kept as simple as possible. How effectively this purpose was attained is shown by the fact that transformer installations were made in the vaults at labor costs of $160 for a 150 kv-a. bank of transformers and $180 for a 200 kv-a. bank with labor at the Chicago union scale.

Wood conduit is used for all underground cables. This consists of 4 in. uncreosoted wood pump logs, laid about 20 in. below the surface of the ground without any concrete envelope or other holding or protective means. The largest run, from the Soldier's Field substation to the Hall of Science, consists of nine ducts, the square conduit simply laid on top of each other in three rows. As far as possible the duct runs are installed mostly in uncovered areas, under lawns and in parkways where sprinkling keeps the soil moist and assists in heat dissipation. This type of construction eliminates entirely the use of concrete and saves at least 50 per cent of the cost. Manholes are from 400 to 600 ft. apart and most of them are made of wood planks. Under roadways where traffic is heavy they are of concrete.

Four sizes of 4000-v. feeders are used 350,000 and 250,000 cir. mil., No. 4/0 and No. 2/0. There are three

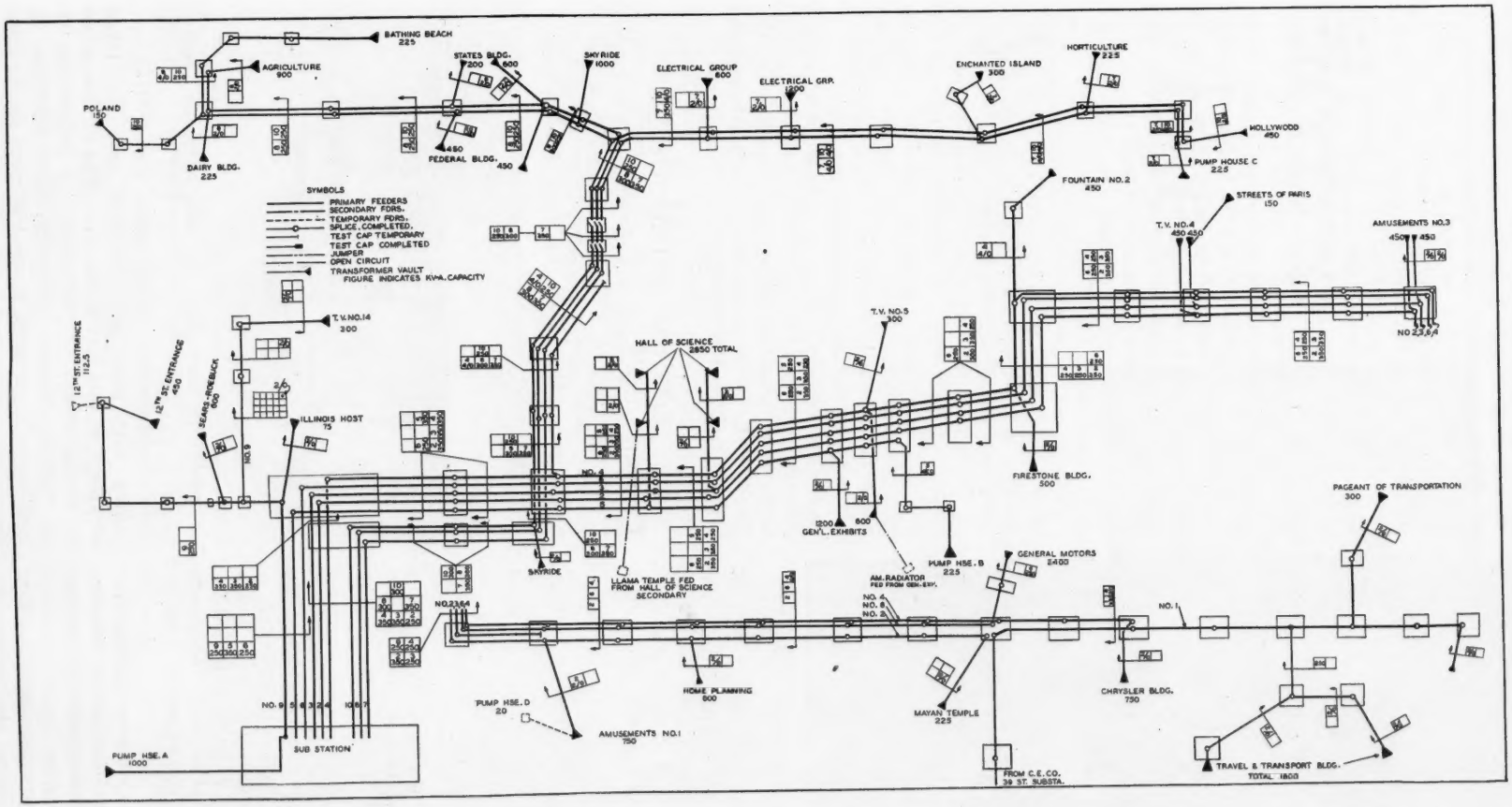


FIG. 1. THE 4000-V. PRIMARY FEEDER SYSTEM AT THE CENTURY OF PROGRESS

The fair is served entirely from the Commonwealth Edison Co. system through two step-down transformer substations, one at Soldier's Field and the other at 39th St. The major part of this power supply is through the Soldier's Field substation, from which 9 cables radiate to the various transformer vaults throughout the grounds. A tenth cable from 39th St. feeds the Travel and Transport Group and the exhibits at the southern end of the exposition grounds.

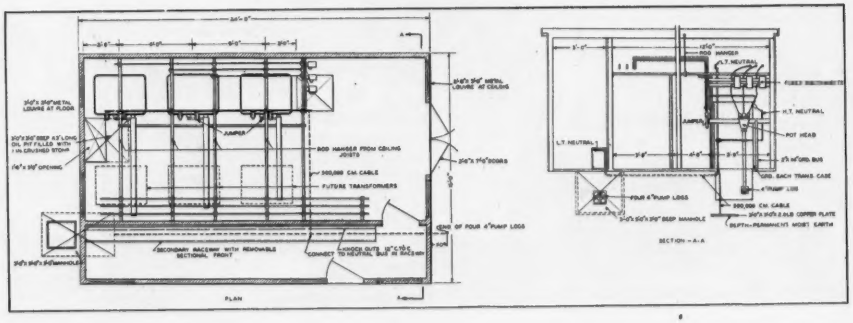


FIG. 2. (Right) FEATURES OF A TYPICAL TRANSFORMER VAULT

The transformer vaults are extremely simple in design, containing no oil circuit breakers, disconnects or metering equipment. It is interesting to know that for a 150-kv.a. bank of transformers, the labor costs for these vaults was only $160 using Chicago union scale labor.

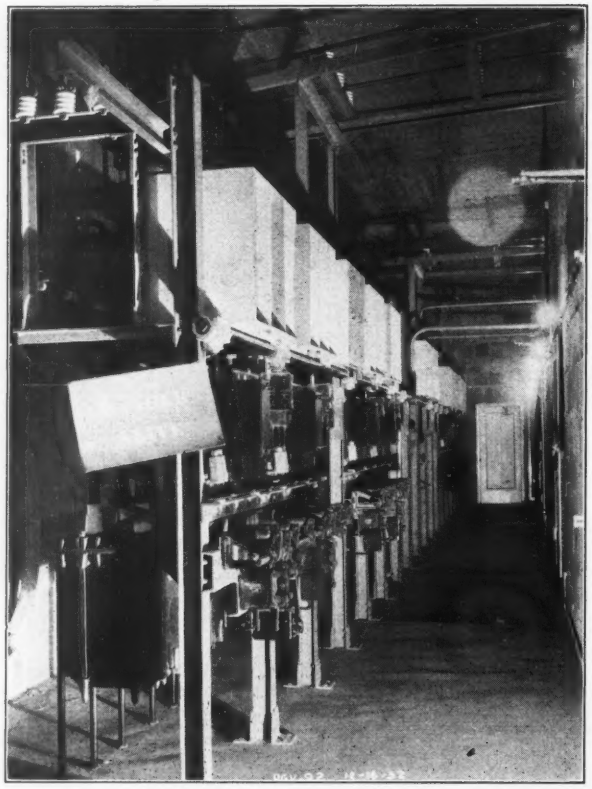


FIG. 3. A VIEW IN THE SOLDIER'S FIELD SUBSTATION

conductor paper insulated cables, lead covered with the lead sheath used for the neutral return circuit. The amount of this cable installed totals some 140,000 ft. None of this was purchased—all of it was rented from the Commonwealth Edison Co. which will take it back at the close of the exposition.

The transformer vaults are extremely simple. They contain no oil circuit breakers, disconnecting switches or metering equipment. The 4000 v. supply simply fans out from a pothead to disconnecting type fuses mounted on the end of the pipe rack which extends over the transformers to support the primary and secondary buses. The primary buses are of rubber insulated cable but the secondaries are bare copper bars. At the points where the secondary bus is supported on the pipe rack insulation is provided by short lengths of fiber tubing slipped over the pipe.

All of the four wire 120/208 v. Y secondaries are installed underground, mostly in pump log except for those feeders whose complete lengths are contained in the larger buildings. Underground secondaries are standardized at No. 4/0 for the phase wires with No. 2/0 for the neutral, the former being lead covered. This standardization of sizes permitted standardization of safety switches at 200 amp. capacity.

The feeders are divided into six groups, which are switched separately. These are classified as follows: Interior lighting, emergency lighting, exterior lighting, power, show windows and concessions.

In the main buildings, the construction again is different from standard practice. There, the feeders are installed in a system of metallic raceways which does away entirely with the necessity for central distribution points or cabinets. This new system was developed by the electrical division of the exposition and its use in the fair buildings represents its first use anywhere. Its cost is only one-eighth as much as the usual conduit installation. These raceways are constructed of 18 gage galvanized metal with 22 gage snap-on covers. The 5x5-in. raceways are installed in 10 ft. lengths and fuse boxes of four-circuit capacity are attached to the sides of the raceway every few feet. This reduces the wiring in the system to less than 30 per cent of the amount necessary with conventional methods of wiring.

As has been mentioned feeders are mostly number 2/0 while circuit conductors are No. 12 wire. Here again a clever scheme was used to reduce labor costs. The specifications for feeder conductors called for a layer of paper tape around the copper to separate it from the rubber insulation. This made it easy to remove the insulation in making splices and connections and thus saved much labor.

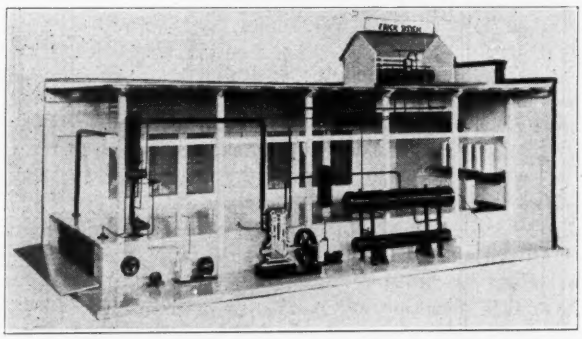
Insofar as possible all wiring was preassembled in the 10 ft. lengths of metal raceways. This raceway was then installed by securing with nails or screws, resulting in a cost of only one-third or one-fourth of any other type.

Throughout the element of cost was carefully considered, not only with respect to material but also with respect to labor of installation and removal. In the case of the underground wood duct for instance, this will not be salvaged when the fair is over; it will simply be left in the ground and the manholes filled in.

Most outdoor lighting is from the building circuits, being fed on special pole lines from the nearest building. Circuits to the lighting standards are installed by plowing in lead covered single conductor cables about one foot below the surface of the ground.

Exhibition Models

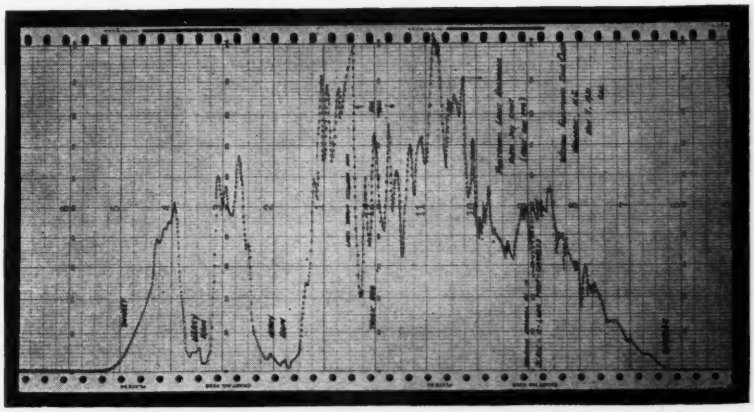
POWER SHOWS and exhibitions have always taxed the ingenuity of manufacturers as the public is extremely fickle and often hard to interest. Moving models, particularly those that show details of opera-



MODEL OF REFRIGERATION PLANT BUILT FOR EXHIBITION PURPOSES

tion and construction always draw a crowd. It is surprising that more manufacturers have not taken advantage of this fact in the past. The exhibit shown by the accompanying photograph was constructed by the Frick Co. for exhibition purposes two years ago. It is of course but a single example of what can be done. Many more can be seen in the World's Fair exhibits which can be studied to advantage by all manufacturers competing for the interest of the public.

Electric Eyes



Watch Over the Power Plant

By ANTHONY H. LAMB
Weston Electrical Instrument Corp.

ALTHOUGH discovered nearly a hundred years ago, the photoelectric effect has not been applied commercially until just within recent years. This effect makes possible the production or control of electrical energy by the action of light. Until the last decade, photoelectric devices were merely toys in the hands of scientists—interesting, but they lacked commercial value because of the extremely small amounts of energy they liberated or controlled. Few relays were rugged and at the same time sensitive enough to permit of the photoelectric devices being applied in industry.

With the development of radio, however, and the invention of the grid-glow tubes and other thermonic devices and of reliable, sensitive relays, coupled with the improved long lived photocell, recently placed on the market, photoelectric applications have become increasingly numerous.

There are on the market today some fifty different makes of photoelectric cells, all of which fall into one of four general classes. The problem confronting the average industrial or power plant engineer who feels he has use for the "electric eye" is not, how to apply the "eye" but rather, which eye is best suited to his purpose. Perusal of current advertisements is often confusing since in many instances similar claims are made for vastly different apparatus; in fact, prices alone sometimes vary from $20 to $200 for equipment purporting to accomplish the same results.

The successful application of the photoelectric effect to any industrial effect requires the selection of a photocell from the proper one of the four general classifications referred to.

Essentially, the photocell is an electronic device similar to a vacuum tube (indeed, the phototube *is* a vacuum tube) in that electrons are emitted, transported, collected and put to a useful purpose by means of a suitable circuit. In the ordinary radio vacuum tube, heat causes the emission of electrons; in all photocells, the emission is caused by light even though in some instances the light may be invisible to our eyes, that is it may be in the ultra violet or infra red range.

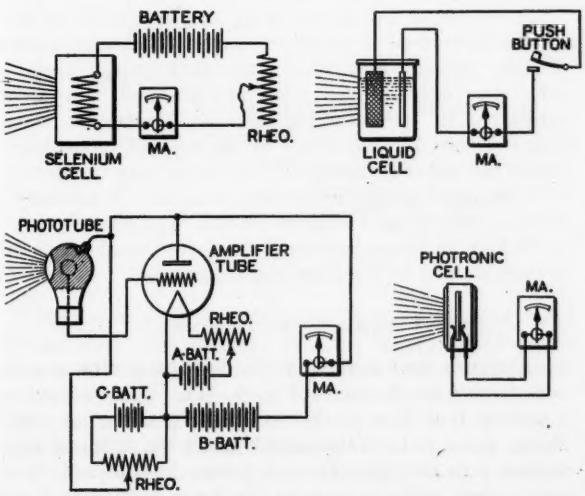


FIG. 1. SIMPLE CIRCUITS USED WITH THE DIFFERENT CLASSES OF PHOTOCELLS

Four Classes of Photocells

The Selenium Cell (Photo Conductive Cell) is one of the oldest and best known cells available. It is merely a resistor and conducts electricity which is supplied by a battery or generator. The ohmic resistance of the selenium cell varies with the intensity of light to which it is exposed and by the resulting variation in current, its use as a light sensitive control device is made possible.

Although the selenium cell has been improved in recent years, it has a high temperature coefficient and is rather unstable and subject to continuous drifting. It has a large dark current causing continuous drain on the battery and any circuit in which it is used must be readjusted continuously. To compensate for these undesirable characteristics it offers a larger current change than any other type of photocell and is suitable for use where it can be watched closely.

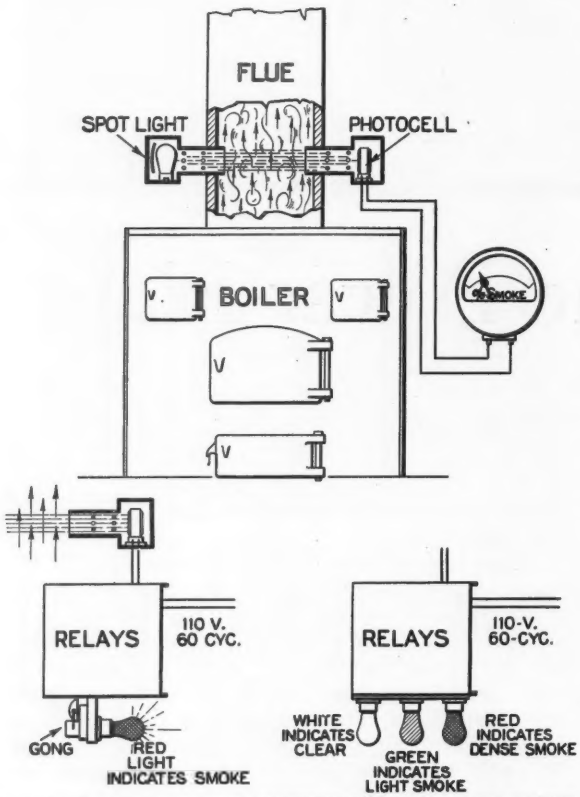


FIG. 2. PHOTRONIC CELL MOUNTED IN FLUE FOR SMOKE INDICATION

FIG. 3. SIMPLE SMOKE DENSITY INDICATOR AND SMOKE ALARM CIRCUITS

The Photo-Voltaic (Liquid Cell) is similar to a wet battery in that it makes use of two plates, or electrodes, and an electrolyte. No external battery is required and exposure of the sensitive surface to light causes a current to flow. This cell has a high current output but when current is drawn from it a gas is generated and the cell becomes unstable and worthless in a short time —sometimes a few days but at most a few weeks. This cell is useful only where it will be in circuit for a few minutes at a time, and is standardized frequently. When not in use the circuit must be opened.

The Phototube (Photoelectronic Cell) is an evacuated or slightly gas filled, glass or quartz tube the inner wall of which is coated with a light sensitive surface, usually one of the alkali metals, sodium, potassium or caesium. This surface forms one (the cathode) of the two electrodes. The other electrode (the anode) consists of a collecting ring or post insulated from the rest of the cell. A window or transparent area in the tube permits light to impinge upon the light sensitive material, causing it to emit electrons. These electrons are attracted to the collecting electrode which is maintained at a positive potential by a battery.

These cells have a low current output, usually in the neighborhood of 10 to 20 micro-amperes and rarely exceeding 75 micro-amperes. They require considerable voltage and a vacuum tube amplifier for their operation, but are practically instantaneous in their operation. The vacuum phototube is easily capable of response to fluctuations of light as frequent as 200,000 per second. It is therefore admirably suited to sound picture work, television and other applications requiring high frequency response. Due to the need for an amplifier circuit, their application is somewhat more complicated and delicate than other forms of photocells, and it is difficult to apply them, except as a unit, by one not having special training. Compact, assembled units are on the market however, which have simplified their application considerably.

The Photronic Photoelectric Cell is the latest development of the photoelectric art and is the first batteryless, dry plate, break proof cell on the market. This cell consists simply of a flat metallic disc which when exposed to light causes a direct transformation of light energy into electrical energy. It is best suited for use where it is desired to connect the photocell directly to a relay, indicating instrument, or recorder.

This cell produces a higher current output than the phototube and less than the selenium cell or the liquid cell. However, when one Photronic Cell doesn't produce enough electricity to operate the desired device two or more cells may be connected in parallel as is done in making a common dry cell battery. It is slower of response than the phototube and for this reason this cell is not suited for sound picture work, television, etc. It is ideal for such uses as direct connection to a relay, instrument, etc., and where a battery or amplifier is not desired.

Smoke Measurements

Smoke density measurements are valuable to any power plant as a smoking fire is indicative of improper combustion. In most instances the fireman cannot see the stack without leaving the building and even when the stack can be viewed from the boiler room, dark nights prevent sight; and constant watch must be maintained even throughout the day.

A simple device to warn of smoking consists of a spotlight mounted on a flue or stack and throwing a beam of light onto an electric eye mounted on the opposite side. The electric eye, which is connected to a meter calibrated in "Percent Smoke" or Ringelman Units, then watches for any trace of smoke and immediately causes the meter to indicate. This meter may be mounted with the other gauges used with the boiler. A continuous recorder can be used with or instead of the meter.

Where an alarm is desired or where signal lamps are preferable to a meter these can be installed.

Water Level Indicator

A simple and reliable water level indicator may be constructed as shown in Fig. 4. The light beams are aimed so that they strike the gauge glass at an angle. When there is no water in the glass the beam of light strikes straight through and passes by the cell; however, when water is present the beam is refracted and falls directly on the cell causing meter to indicate. There

may be any number of cells and the meter will read in direct proportion to the number of cells illuminated, thus indicating the height of water in the glass.

If a simple alarm is desired it is only required to use one light beam as explained above, or a float may be used. When the predetermined low level is reached the float intercepts the light beam and causes relay to ring gong and turn on red light.

Warning of Coming Load

Power plants producing electricity for lighting purposes may be forewarned of a coming demand by use of photocell mounted outdoors at any remote point, several miles away if that is where the light will be used, and connected to an indicator or recorder in the boiler room. The meter may be calibrated in light intensity units (foot-candles) and when a predetermined minimum is reached steam may be made ready, to produce the load that will follow. Some evenings darkness approaches as much as an hour earlier than sunset—on days of sudden storms the darkness may be equal to night.

The recorder chart shown in the illustration at the head of this article is an actual record obtained on a stormy day. When the illumination outdoors drops below 200 ft. candles the lights in any home, office or factory must be switched on if work is to be continued. The chart shows clearly the approach of unexpected darkness at 1 o'clock and again at 3 o'clock; and then at 4:15 as sunset approaches. Where desirable an alarm is connected to this device and arranged to ring a gong and turn on a red light at the predetermined value of darkness.

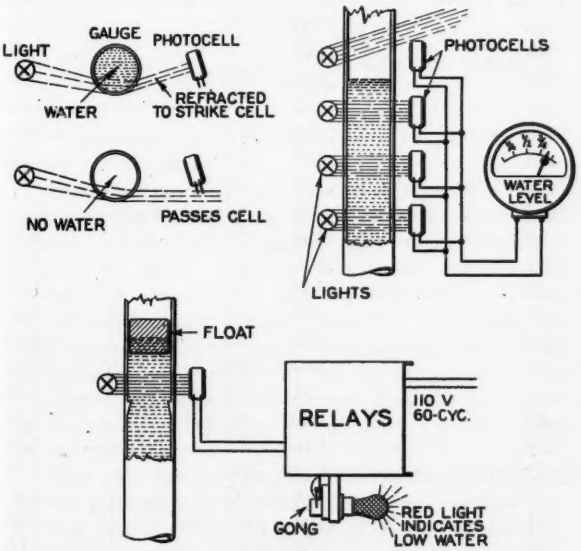


FIG. 4. WATER LEVEL INDICATION

Similar devices may be used to open doors so hand trucks may pass through without stopping, to count objects on conveyors, etc., to control operation of automatic machinery or to give warning of danger.

A photoelectric door opener consists of a spotlight, a photocell relay and a hydraulic door opening device. It may be arranged so that interception of one light beam causes the door to open and remain so until the second light beam is intercepted, or, as an alternative, only one light beam is required and the door is arranged to remain open a few seconds before reclosing. The same equipment may be used to count moving objects by connecting an electric counter in place of the door opening motor.

The few pictures and applications shown are not new but are finding the most widespread use and they will serve to illustrate to the reader that the photocell is no longer a toy, but instead, is taking a prominent place in our industrial life. The possibilities of putting the photocell to work have barely been sensed. Only when the action of light-sensitive devices has become common knowledge to our pioneering engineers can we hope for any great commercial usage of this relatively modern instrument of industry.

New Types of Circuits

Recent experiments in the General Electric Research laboratory have brought to light non-linear circuits which are oscillators or generators of alternating currents, in such respects functioning like vacuum tubes. One circuit produces such slow oscillations that an incandescent lamp is turned on and off if placed in the circuit, several times per second or as slowly as once in thirty seconds, according to the arrangement of the circuit. One such oscillator has blinked a light on and off silently, without radio interference, and without wearing parts, approximately 100,000,000 times in the past two years while on life test in the laboratory. There is nothing to wear out.

Another oscillator produces relatively high-frequency alternating current. It was known for some time that high frequencies could be produced in transformers under certain conditions, but these frequencies are always multiple or integral fractions of the frequency of the power supply. The new oscillator will produce any frequency in its range of usefulness; vibrations of 5000 cycles per sec. already have been observed audibly in the laboratory.

Electricity in 1932 15 Per Cent Less Than in 1929

Final report on the production of electricity in the United States in 1932 shows that a total of 83,153,000,000 kw-hr. was produced for public use in 1932. Of this total 41 per cent was produced by the use of water power and 59 per cent by the use of fuels. The proportion of the total output produced by the use of water power was more in 1932 than ever before.

In 1932 the total output was 9.4 per cent less than in 1931, which in turn was 4.4 per cent less than in 1930, and the output in 1930 was 1.5 per cent less than in 1929, the year of maximum output. The output by the use of water power in 1932 was 11.4 per cent greater than in 1931, and the output by the use of fuels was about 20 per cent less than in 1931. The total output in 1932 was about 14.5 per cent less than in 1929; the demand for electricity has therefore held up remarkably well in comparison with other industries during the 3 yr. of the depression.

Increase in efficiency in the use of coal, oil and gas in the generation of electricity, which has been accomplished consistently each year since 1919, was continued during 1932.

POWER PLANT ENGINEERING July 1933

This thing called POWER FACTOR—

Part VII. A final discussion. The difference between synchronous and induction motors with respect to power factor. Effect of mechanical load on synchronous motor action.

I SAY, OLD TIMER, have you got a few minutes before you go home to give me some more dope on power factor?"

Without waiting for a reply, Val, the ambitious young chemist, sat down opposite the chief engineer's desk and waited until the latter finished some calculations he was making.

"Sure," said the chief finally. "Shoot! What's on your mind now? I thought you knew all about power factor now."

"None of your sarcasm, old boy. I came here for information, not to be insulted, so don't try to high-hat me. Now, there are several things I want to know. To begin with, why does one type of motor affect power factor and not another? Don't all motors operate by virtue of magnetic fields set up around their windings?"

"Yes," said the engineer, "that's quite correct. Motors of all kinds rotate because of the reaction of two magnetic fields. One of these fields is established by the 'power' current—that is, current which is transformed into mechanical power, and the other by the magnetizing current. This magnetizing current, as we have seen, does no useful work but it must be supplied to the motor either through the power lines or from some other source."

"Now, an induction motor, as you know, gets its entire electric current supply from the lines connected to the stator winding. Thus, these wires must carry both the 'power' current and the 'magnetizing' current."

"Isn't that true of all motors or electrical devices?" asked Val.

"No," said the chief. "It is not true of a synchronous motor. In such a motor the magnetizing current is supplied from a different source, usually from a direct-current exciter. The line wires carry only the power current. Another thing, you asked whether it is not true of other electrical devices. Some devices don't require magnetizing current. Incandescent lamps, for instance, need no magnetic field of any kind for their operation; neither do electric heaters of the resistance type; hence, such devices constitute high power factor loads.

"Now if you recall, in our previous discussion[1] I showed you by means of a vector diagram that the magnetizing current of an induction motor remains practically constant regardless of the load on the motor, so that the lower the load the lower the power factor. In other words, it is the proportion of magnetizing current to the power current that determines the power factor. Indeed it is quite easy to make a table such as this (see accompanying table) giving the power factor for various ratios of magnetizing current to 'power' or effective current."

"I see," said Val, as he studied the table which the chief engineer had found in a handbook, "but of just what use is this? How do you know what this magnetizing current is? Can you measure it?"

"Yes, you can," replied the engineer, "that is, you can measure the reactive power, by what is known as a reactive wattmeter. However, you don't have to know about that, although such instruments are very useful in making adjustments of field strength on a rotary convector for unity power factor. Such adjustments are made with greater precision with reactive wattmeters than when a power factor meter is used. But to get back to our discussion of motors—you now understand the difference between an induction motor

TABLE SHOWING VALUES OF POWER FACTOR FOR VARIOUS RATIOS OF MAGNETIZING ITS EFFECTIVE CURRENT

Power Factor	Ratio	Power Factor	Ratio
1.00	000	.79	.776
.99	.142	.78	.802
.98	.203	.77	.829
.97	.251	.76	.855
.96	.292	.75	.882
.95	.329	.70	1.020
.94	.363	.69	1.049
.93	.395	.68	1.078
.92	.426	.67	1.108
.91	.456	.66	1.138
.90	.484	.65	1.169
.89	.512	.64	1.200
.88	.540	.63	1.233
.87	.567	.62	1.265
.86	.593	.61	1.300
.85	.620	.60	1.333
.84	.646	.59	1.369
.83	.672	.58	1.404
.82	.698	.57	1.441
.81	.724	.56	1.480
.80	.750	.55	1.518

[1] April, 1933, issue, p. 178.

and a synchronous motor so far as magnetizing current is concerned, don't you?"

"Yes," said Val, "in the synchronous motor the magnetizing current is supplied by the exciter, thus relieving the lines of carrying this current."

"That's right," interrupted the engineer, "and remember, this 'reactive' current requires copper just the same as does the power current. The resistance losses of conductors are proportional to the square of the current."

"Does this reactive or magnetizing current affect the generator supplying the system as well as the line itself?" asked the chemist.

"Yes," explained the engineer. "Low power factor reduces the capacity of the generator. Usually, alternators are furnished for 0.8 power factor operation. The full load kilowatt capacity is then 80 per cent of the rated kv.a. capacity, provided 0.8 power factor is maintained. If the power factor is lower the stator winding must carry the increased reactive current. To generate this magnetizing current and at the same time maintain normal voltage requires increased magnetization or excitation from the field windings. The field current, however, is limited by the heating of the windings."

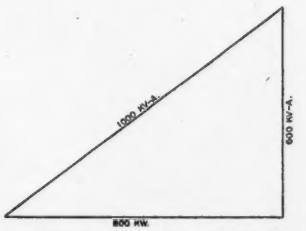


FIG. 1. VECTOR DIAGRAMS OF AN 800 KW. .8 LAGGING POWER FACTOR LOAD

"A generator is very much like a synchronous motor, isn't it?" asked Val.

"Yes, exactly; a synchronous generator will run as a synchronous motor when supplied with power from a circuit. It is for this reason that synchronous motors can be used to correct low power factor—they generate the magnetizing current required by inductive equipment. By over-exciting the fields they can be made not only to neutralize the lagging reactive current of induction motors but also to supply an excess of magnetizing current which can be used by induction motors, thus relieving the generator of supplying that amount."

"Will they supply this reactive current even though they are pulling load as a motor?"

"Yes, but of course the amount of leading reactive current the motor can supply under such conditions is less than when operating without load. In other words, the amount of leading reactive kv.a. that a synchronous motor can supply depends upon its mechanical load and its field excitation. The limit is reached when the leading reactive kv.a. equals the total kv.a., in which case there is no power available at the shaft and the unit operates as a synchronous condenser."

"I see," said Val. "Then in order to improve the power factor of the system the synchronous motor must operate at the 'leading' power factor—at unity power factor it would not improve the power factor of the system. Is that right?"

"No," corrected the chief. "Even at unity power factor the synchronous motor improves the power factor of the system. Here, let me show you by means of a diagram. Suppose we have a 1000 kv.a. 0.8 lagging power factor induction motor connected to a system. Such a motor would have a useful power load of 800 kw. and a lagging reactive power load of 600 kv.a. as shown in this diagram (Fig. 1). See?"

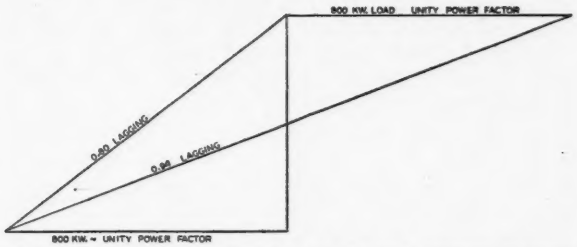


FIG. 2. EFFECT OF ADDING AN 800 KW. UNITY POWER FACTOR SYNCHRONOUS MOTOR TO THE LOAD SHOWN IN FIG. 1

"Yeah," said Val. "Go ahead."

"All right. Suppose now we add to the system an 800 kw. synchronous motor load operating at unity power factor. What happens? Well, let's add this to our diagram."

For a moment the chief busied himself drawing, and finally produced the diagram shown in Fig. 2.

"There," he said, "you see what has happened? By adding an 800 kw. load at unity power factor, the power factor of the system as a whole has increased from 0.80 to 0.94. In other words, unity power factor motors improve power factor by increasing the total kv.a. without adding to the reactive kv.a. In effect, what we are doing is increasing the ratio between the magnetizing and effective current."

"That's fine, chief," exclaimed the chemist. "I see how it works—the more load you add at unity power factor, the higher the power factor."

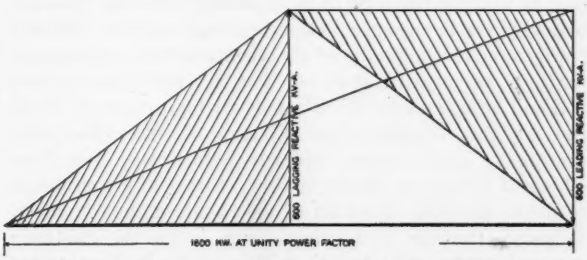


FIG. 3. EFFECT OF OPERATING THE 800 KW. SYNCHRONOUS MOTOR AT .8 LEADING POWER FACTOR

"Correct. Now, suppose instead of operating the synchronous motor at unity power factor we make it operate at 0.8 leading power factor. In this case, we draw the line representing 600 leading reactive kv.a. down from the end of the diagram shown in Fig. 2. That is, we get this condition (Fig. 3). Here, you see, the lagging reactive kv.a. of the induction motor is exactly neutralized by the leading reactive kv.a. of the synchronous motor, bringing the power factor of the system to unity. Of course, you understand that in

order to make the synchronous motor operate in this manner, the excitation current must be increased."

"Yes, I understand that," said Val. "In fact, I have a pretty good idea now of the whole problem of power factor correction—that is, I understand the fundamental principles involved. I may not be able to calculate all the problems in power factor but with the aid of the diagrams and examples shown in many of the manufacturers' handbooks, I think I can solve most of those that may come up in my department."

"Well," said the engineer, starting to clear up his desk, "that's what I tried to explain. There are many books and articles available which explain methods of calculating power factor; indeed, some years ago a whole series of articles on this subject was published in Power Plant Engineering[2] so there is no need of going into detail about calculations here. What I have endeavored to bring out is what actually happens in the circuit—how energy is stored up first in the electromagnetic field, then in the electrostatic field and how the interchange of energy is brought about. If you can understand how it is that synchronous motors or condensers furnish leading reactive kv.a. in cycles timed directly opposite to the cycles of lagging reactive kv.a. of induction motors and if you understand the mechanical analogies I pointed out, you need never by mystified by what the term power factor means. Also, if you understand that the various terms—reactive current, counter e.m.f. induction components, etc.—are only imaginary conceptions, you need never be confused about how more than one current or voltage can exist in one circuit at one time. There can be only one current and one voltage in any circuit at a particular instant. If you remember nothing else, remember that —it's very fundamental."

[2] The Reactive Component in A. C. Circuits, by V. E. Johnson, published from February, 1928, to January, 1929.

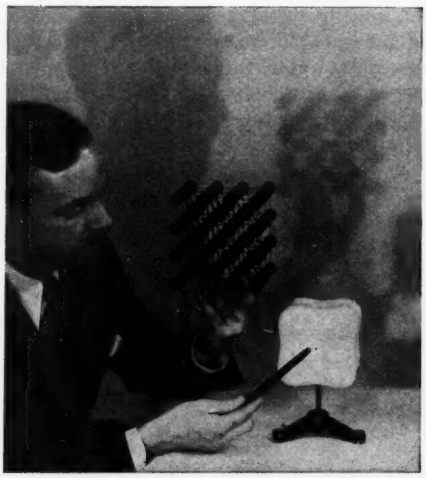
Magnetized Atoms Actually Oscillate

MAGNETIZED ATOMS OF IRON, whose directional force was heretofore thought to be dead and dormant are now believed to be very much alive and active. Theory explaining the behavior of atomic structures when magnetized, universally accepted for the past 50 yr., was claimed erroneous by Dr. Francis Bitter, research physicist of the Westinghouse Electric & Manufacturing Company, in a recent address before the American Physical Society at Atlantic City. Bitter offers evidence to prove that the direction of an atom's magnetic force, formerly thought to be stationary, is on the contrary constantly changing and that it oscillates in the manner of an automobile's windshield wiper but much faster.

He rejects the earlier hypothesis that atoms in a piece of magnetized iron obey static laws, or laws of forces at rest. Static laws apply to buildings, bridges and other structures not in motion. He claims that the magnetic iron atoms are governed by dynamic laws, or laws of forces in motion. The movement of the sun, earth and planets, and all moving or rotating machinery are governed by dynamic laws.

Observation of the fact that the magnetization of an iron bar changed if the bar is twisted or strained in any way led to his doubt of the static theory. By the static theory, distortion of the metal's crystal structure should not affect the bar's magnetization. By assuming that an atom's direction of force oscillates and by applying dynamic laws to the magnetization theory, he was able to explain many manifestations of magnetic phenomena and predict the magnetic property of an atom under all conditions of the magnetic field.

To illustrate his theory, Bitter exhibited several models. A crystal of iron is represented by a large cube made up of many small black wooden balls, each ball representing one atom of iron. The magnetic property of a crystal is represented by a number of plaster casts, one for each condition of the magnetic field. The plaster cast should be thought of as a plastic mass which easily changes its shape to conform with the demands of the magnetic field or external forces acting upon the atoms of a solid. Models illustrate his theory as follows:



DR. FRANCIS BITTER SHOWN WITH A MODEL OF A CRYSTAL OF IRON, AND A PLASTER CAST REPRESENTING THE EASE OF MAGNETIZATION OF AN IRON CRYSTAL

When a crystal of iron is not subject to any external magnetic influence, its ease of magnetization may be represented by a plaster cube with rounded corners and a depression or hollow in each face. When external magnetic field or other force acts upon the crystal the plastic mass conforms to its influence. As the field changes in strength and direction, the plastic mass changes its shape. Sometimes its shape is symmetrical and regular, other times grotesque and irregular, suggesting the work of certain futuristic schools of art.

As the plastic mass changes in shape, the hollows on it also change in shape, depth and position. Usually there is one of greater depth than the others and this one determines the direction of the crystal's magnetization.

Many leading scientists agree that Bitter's developments, and the concepts of basic physical theory evolved from them, opens up an entirely new field to scientists in exploring the properties of solids. His findings may profoundly affect the design of all kinds of electrical equipment, particularly those employing magnetic principles, and may even extend to metals in every mechanical or structural use, because his theory interprets the changes in crystal formation of metal when it is subject to twisting, bending or other stresses.

Maintenance of Elevator Governors

CRYSTALLIZATION AND BEARING WEAR ARE FACTORS THAT MUST BE WATCHED IN ELEVATOR OPERATION. By C. K. EDGAR

ELEVATOR governors are employed for protection in case of parted cables, and for the failure, disengagement, or separation of the hoisting machine and its parts. Since elevator safety depends on the governor, it should be kept in the best condition so it will operate properly when called upon.

Little attention has been given to fatigue and crystallization of metals on elevators, with the exception of cables, but recent experience on governor repairs has shown crystallization to be a condition needing attention.

CRYSTALLIZATION

In governors of fly-ball type, Fig. 1, rotation of the fly-balls is produced by transmitting the motion of the governor cable to the spindle through a combination of bevel gears and a drive sheave. These gears and sheave fit tight on their respective shafts and are most usually forced fits. After the governor has been run for some time, however, the sheave and gears gradually become loose and work on their respective shafts. To insure positive action, the drive sheave and gears are made fast to their shafts by taper pins.

Many times vibration, caused by the gears and governor cable, crystallizes the taper pins, so that eventually they become fractured, sometimes before it becomes evident that the gears and sheave are working upon their shafts.

In overhauling one governor, the taper pins, when removed, were found broken into as many as four pieces. Inspection of the other governors on the same installation showed that all were in the same condition. As the wear between gears, sheave and shaft was too little to demand new shafts, the old taper pin holes were reamed out and new pins installed, which held the gears and sheave tight upon the shafts and prevented them from working.

BEARING WEAR

Bearing wear of governors is important, as badly worn bearings will cause the governor to become inaccurate and may cause unnecessary governor tripping. Worn bearings on any type of governor will fail to retain lubricant and distribute it evenly and correctly.

On pedestal bearings, pressure is continuously downward from the cable and tension-sheave weight. When the clearance on the top half of the bearing becomes large from wear, the downward pressure of the shaft has a tendency to prevent lubrication on the bottom of the bearing and confine the lubricant to the large clearance above. This condition often causes bearing seizure.

When worn, the vertical shaft or spindle bearing will not retain lubricant because of its vertical position. Not only may this subject the governor to bearing seizure but it may have an effect on governor accuracy. Erratic action and pre-required tripping of the governor is often the fault of worn bearings, especially where the elevator accelerates rapidly. Excessive bearing wear should be repaired and lubrication should never be neglected.

CABLE GRIPS

Governor cable-gripping jaws are designed so that they are independent of normal motion of the governor-actuating lever. When the elevator speed becomes excessive, the governor-actuating lever rises to a point where it trips the governor jaws and they automatically fall, gripping and arresting the motion of the governor cable. This should occur only for emergency conditions and excessive elevator speeds, which seldom happen, therefore it is seldom that the cable-gripping jaws operate. If they are neglected, dirt and corrosion will ensue, preventing free operation when they are needed. This condition should be avoided by working the jaws at intervals and keeping them well lubricated.

When governors are new they are tested, set and often sealed, for a determined tripping speed but, after running, the various parts naturally become worn. To insure against loss of accuracy caused from parts worn or out of alinement, a test should be made at intervals. The period between tests will vary with conditions but should be short enough to ensure governor accuracy. These tests should be made by an experienced elevator engineer or service man.

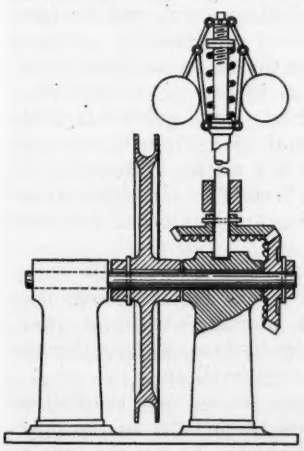


FIG. 1

FIG. 1. ARRANGEMENT OF FLY-BALL ELEVATOR GOVERNOR

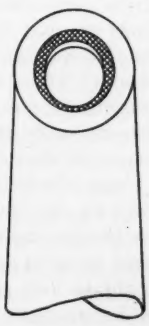


FIG. 2

FIG. 2. PEDESTAL BEARINGS WEAR

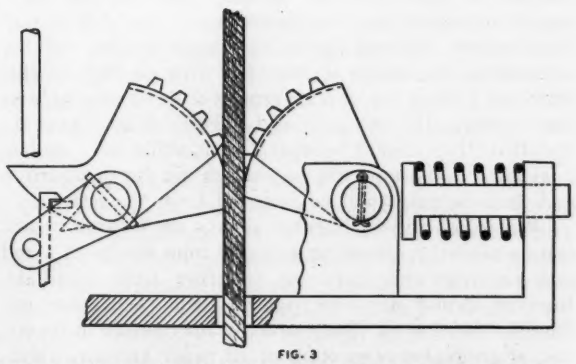


FIG. 3

FIG. 3. CABLE-GRIP MECHANISM SHOULD BE IN GOOD ORDER

POWER PLANT ENGINEERING July 1933

Part III. Operation, Maintenance, Economy Require Caution, Adequate Records and Careful Attention to Routine.

OIL FUEL FIRING *and* Combustion Equipment

By
E. G. Peterson*

OPERATION of an oil fired boiler plant differs little in its essential principles from that of a coal fired plant. For best economy and lowest steam production costs, it is necessary to give either installation careful attention both as to operation and maintenance of equipment. The application of information obtained from adequate records and the establishment of routine methods in the handling of fuel and equipment form the basis of economy and simplicity in the functioning of the plant.

Starting New Plants

When starting up a new installation it is a good plan to circulate hot oil through the system for several hours before attempting to light off burners. This not only assists in flushing dirt and scale from the piping, but also permits the operators to become familiar with the auxiliaries and the location of valves. During this period of circulation, the strainers should be inspected and cleaned at intervals. Relief valves, pump governors and temperature controls should be given their proper adjustments.

Before lighting burners, make certain that the boiler damper is open and the furnace has been properly vented to remove any accumulation of gas. Oil should be circulated through the boiler supply header and the circulating line which is provided with all fuel oil systems until oil at the proper temperature is available at the burners. If induced and forced draft fans are installed, they should be operated at sufficient speed to guarantee that there will be enough air for combustion and that the gases will be removed from the setting.

When lighting off burners always use a torch, which can be made by attaching asbestos rope firmly to a rod and soaking with kerosene or other light distillate. Burners should never be lighted from each other nor from hot brickwork. Such practice may result in formation of an explosive mixture of oil vapor and air, which, upon igniting, can cause severe damage to the boiler setting and endanger the lives of operators.

If the furnace setting is new and the walls have not been previously dried out by wood fires, heat should be applied to the furnace slowly in order that the walls may have time to dry out before attaining any high degree of temperature. Light fires should be carried over a period of 48 hr. or more, depending upon the thickness of walls and their dryness previous to lighting fires.

Where difficulty is experienced in lighting off the burners or maintaining ignition, it will generally be found that the atomizer or lines are partially plugged with pipe scale. A clean atomizer, a number of which should always be kept on hand, should be inserted and the furnace well vented of gases before again attempting to light.

Adjustment and Operating Routine

When the plant is in operation, a routine should be established for the cleaning of strainers and burners. Suction and discharge strainers are generally provided in duplicate, so that cleaning can be accomplished without interrupting service or by-passing of strainers. Atomizers are usually fitted with quick-detachable couplings so that the removal of a dirty burner and insertion of a clean burner is a matter of seconds. If, immediately after removal from furnace, dirty atomizers are placed tip end downward in a pot of kerosene, they can be easily cleaned.

Atomizers should be set in position so that the spray at all times clears the brick throat, otherwise coke may build up on the throat and interfere with combustion. Burner throats should be inspected occasionally through a colored glass to see that they are clean.

To obtain best results from the burners, the fuel oil should be properly prepared to conform to the operating characteristics of the burners. To this end, pumps and heaters are designed to supply the oil at the correct pressure and temperature. The air chamber employed

*Peabody Engineering Corp., New York, N. Y.

with reciprocating pumps should be charged with air as often as necessary to remove pulsations from the lines efficiently.

Heaters should be controlled, either by hand or by automatic devices which maintain constant temperature or, better still, constant viscosity, so as to heat the oil to the correct atomizing temperature. This temperature is determined by the viscosity of oil, as explained in the previous article on fuels, and will therefore vary with the grade of fuel and, within certain limits, with each delivery of fuel. A viscosity regulator naturally gives more efficient control than the ordinary temperature regulator, as it receives its impulse from changes in viscosity rather than in temperature.

It is important that the steam be shut off from heaters when there is no oil flow through them. Neglect of this precaution may result in rapid formation of carbon in the heaters and a reduction in heating capacity.

Measurement of oil consumption by means of meters or tank level indicators should be checked by gaging the contents of the tank by rod or tape. A table of capacity corresponding to the depth of oil in the tank should be prepared or obtained from the tank manufacturer. From this table, the quantity of oil in the tank corresponding to the depth as read from the rod or tape may be obtained in gallons at the temperature of the oil in the tank. This measurement of volume must be corrected to 60 deg. F. by subtracting 0.0004 of the total volume for each degree above 60 deg. F. If the tank contains 10,000 gal. at 130 deg., the corrected volume becomes $10{,}000 - 10{,}000 \times 0.0004 \times (130 - 60)$, or 9720 gal. at 60 deg. The same correction for temperature should also be made to readings of meters.

BOILER FRONTS AND INSTRUMENT BOARD AT CONSOLIDATION GAS AND ELECTRIC CO.'S PLANT, SAN DIEGO, CALIFORNIA

Sources of Loss

As the largest single loss in the burning of fuel is that heat which goes to the stack in the combustion gases, it is important that every precaution be taken to reduce this item to a minimum. Each pound of fuel requires a certain quantity of air to complete combustion. In addition to the theoretical air quantity, an excess is provided to make certain that no fuel escapes unburned. With a well designed burner, this excess is generally between 10 and 20 per cent; while a poorly designed burner, under some conditions may require between 50 and 100 per cent excess air to complete combustion.

In addition to the air required by the burners, there may be an appreciable amount of leakage through the setting walls. Such leakage is of no assistance in combustion and is a direct loss. Walls should be kept in repair, expansion joints packed and the furnace operated under as low a draft as possible in order to prevent high losses from air leakage. In some cases it is advisable to cover the outer walls with a plastic preparation to seal small cracks.

Every pound of air entering the furnace or boiler setting leaves the boiler at the temperature of the flue gases. The loss in heat is, therefore, proportional to the weight of gases and their temperature and, in order to obtain good fuel economy, it is necessary to maintain both these items as low as possible.

Temperature of the flue gases at the boiler exit depends upon the design of the boiler heating surfaces, the capacity at which the boiler is operated, cleanness of heating surfaces both internally and externally, the location and tightness of the baffles and the percentage of excess air.

For any given boiler design and operating capacity the exit gas temperature will increase as heating surfaces become dirty. Leaky baffles, permitting short-circuiting of hot gases from one pass to another, contribute toward high gas temperatures. Excess air, beyond that actually required for combustion, adds to the heat carried by the gases leaving the heating surfaces and should therefore be kept down to minimum requirements.

In many plants, which operate entirely on hand control of fuel and combustion air, economy depends almost entirely upon the vigilance of the fireman. Instruments indicating the boiler output and the flow of combustion air or the percentage of carbon dioxide in the flue gases can be of great assistance to the fireman in maintaining economy. The fact that the quantity of the fuel may be closely regulated and any desired rate of fuel feed accurately and easily maintained, permits of operation at

efficiencies hardly attainable with hand-fired coal installations. Such instruments, when kept in good repair and adjustment, can, therefore, if their indications are followed, effect substantial savings in fuel and soon pay for themselves. Controls and instruments should be conveniently located as illustrated.

Flue Gas Testing

Regular use of an Orsat flue-gas-testing apparatus is an important aid to economical operation, as by no other means can actual furnace conditions be so accurately determined. Such accurate testing is occasionally required for the proper setting of instruments that may be provided, including CO_2 recorders. Where instruments are not provided and burners are set by viewing the flame through furnace peep holes, the Orsat is needed to check results of oil and air adjustments and to train the fireman in judging furnace conditions by eye. The Orsat is also useful in estimating the amount of air leakage through the setting walls, by taking samples at various points along the path of the gases and noting the extent of the dilution of the gases with air. All such readings, to be comparable, must be taken for the same air-flow and fuel setting of the burners.

Gas samples for the purpose of determining combustion conditions, should be taken at points in the gas flow at least 3 ft. from the setting walls in order to be representative. The line to the Orsat must be entirely free from air leakage. Solutions in the Orsat should be maintained at proper strength in order that complete absorption of the gases may take place. Each sample should be tested for CO_2, O_2 and CO.

The total air, in percentage of that theoretically required for complete combustion, can be calculated from the Orsat determination as follows:

$$\text{Per cent total air} = \frac{100 \times N_2}{N_2 - 3.78\ O_2}$$

where $N_2 = 100 - (CO_2 + O_2)$. It will be noted that these equations do not account for CO in the sample, for the reason that for economical operation there must be no CO in the gases. Sufficient excess air must be provided to burn the fuel completely. When CO is present in the combustion gases, the heat loss will be many times the amount indicated by the percentage of CO, due to the escape of unburned hydrocarbons as well as CO in the stack gases.

Especially is the Orsat valuable in maintaining the efficiency of CO_2 indicators or recorders. Not only is it necessary to check the indications of such instruments, both as to correctness of the instrument and tightness of the gas sampling line, but also in determining the correct percentage of CO_2 to be maintained. Some fuel oils have a higher carbon-hydrogen ratio than others and will therefore require that a higher CO_2 be maintained for the same economical percentage of excess air.

It should not be assumed, on the basis of the stress that has been laid upon the importance of careful operation of an oil burning system, that it is difficult to maintain economical firing conditions. On the contrary, operation with oil fuel is so convenient and simple that comparatively good results can be obtained with a minimum of effort; so much so, that the operator may lose sight of the fact that, by exercising a certain amount of care and by applying a little time and thought in making the tests mentioned above, uniformly excellent results are obtainable. In a well-operated plant, high efficiencies are the rule. When an increase in cost of steam generation is noted, the cause of this increase is to be determined and corrected. By familiarizing themselves with and putting into practice the principles of good operation, operators are in a good position to isolate the condition accounting for higher fuel consumption and correct it.

Washing Deposits from Turbine Blading

IMPURITIES in feedwater tend to build up on turbine blading and first stage nozzles and in certain sections of the country have caused considerable difficulty. In the south and southwest, soda deposits with superheated steam have been reported in a number of plants of steam pressures below 450 lb.

These deposits can usually be removed by washing with boiler feedwater during overhaul periods, by partially filling the turbine with water and slowly revolving the spindle or by dissolving the deposits with wet steam. Methods used by the Florida Power and Light Co. at its Lauderdale Station are described as follows.

A finely powdered deposit was noted on the blading extending from the first through the sixth stage when the machine was overhauled in April. Deposit was highly soluble and readily removed by washing. Chemical analysis revealed that it was composed principally of sodium chloride and sodium carbonate with a relatively small quantity of sodium sulphate. In May the machine was again placed in service with normal first stage pressures, or approximately 198 lb. at a load of 18,700 kw.

One month later under the same load the first stage pressure was 325 lb. and continued to show slow but steady increase. After some investigation, experiments were made with a scheme of introducing into the turbine casing saturated steam into which water is injected. A small jet of steam from the saturated steam header is introduced into the turbine casing at the first stage through the pressure gage connection. Just ahead of the connection to the turbine a syphon connection in the steam line permits the introduction, into the steam line, of variable quantities of water.

By varying the relative quantities of steam and water a vapor is formed within the turbine casing, which condenses on the turbine blading and washes away the soluble deposits. The injections of steam and water into the turbine are carried out with the machine at rest. At the initial trial, several hours of injection of steam and water reduced the first stage pressure from 230 to 200 lb., indicating practically complete removal of deposits on blading. Of the methods for the removal of soluble deposits from turbine blading tried, the above has proved to be most satisfactory and is now employed regularly.

Experience during the past 2 yr. has indicated that frequent starting and stopping of turbines removed a sufficient amount of the salt deposits from the blading to prevent excessive increase in stage pressures. However, during periods of long continued operation without interruption, the salt accumulations appear to increase slowly but steadily. Frequent stage pressure tests are made to determine the rapidity of accumulation of deposits on blading and blades are washed when these tests indicate noticeable increases in first stage pressure.

Water Conditioning in Raw Water Ice Plants

A Practical Outline of the Needs and Methods of Water Conditioning from the Standpoint of the Ice Plant Operator. By R. E. Summers, Dept. of Mechanical Engineering, Oregon State Agricultural College, Corvallis, Oregon.

THERE IS MUCH in the study of water conditioning of interest to the water supply engineer, the boiler operator, the laundryman and the refrigerating engineer. While there are common problems in the fields of those individuals, there are again problems peculiar to each of the fields. It is the present purpose to outline some general principles of water conditioning and then from them to reason into the difficulties encountered with water in the manufacture of raw water ice.

When you measure your height you must have knowledge of the unit employed, perhaps the inch, if the figure that you obtain is to have real meaning. If you are told that a certain man is 200 cm. tall you have little notion of his size unless you are accustomed to the metric system. When you measure your weight you probably prefer a familiar and convenient unit, the pound, even though tons could be used. So when you measure impurities in water or chemicals for water treatment you will find it desirable to use proper units. The chemist and the engineer, never speaking one another's language fluently, disagree somewhat, so that two systems of weight measure are used. The chemist prefers relative impurity concentration as parts, by weight, of the various materials in a million parts of otherwise pure water. The engineer, accustomed to more objective weight units, uses the term grains per gallon.

Now if you remember the weight and measure tables from arithmetic you will recall that the grain is a weight so small that exactly 7000 gr. is the equivalent of a pound. You could then calculate that 1 gal. of pure water, weighing 8⅓ lb. weighs nearly 58,300 gr. A million grains of water would equal 17 gal., or the chemist's measure of weights of impurity in a million weights of water will when divided by 17 give grains per gallon. The measure of grains per gallon is therefore reduced to pounds of material in 10,000 gal. of water by dividing grains to the gallon by 0.7.

Hardness

Water that is said to be "hard" is water that contains certain mineral matter. Mineral matter is dissolved in the water and because it comes out when and where it is not wanted or because it often acts on useful chemical material that we may add to the water (soap for instance) it can be troublesome indeed. It appears as scale in tea-kettles and in boilers, it destroys the action of soap in the household and it clouds ice into which it is frozen. Although dissolved compounds of many of the metals will cause hardness in water only a few such compounds are persistent offenders. These are chiefly the carbonates, bicarbonates, sulphates, and chlorides of calcium and magnesium. Before studying them in detail it is well to note how they are classified or grouped as to origin and behavior. Hardness is said to be "temporary" and "permanent". The terms are now absolutely meaningless and not significant, but like the buttons on a man's coat sleeves, custom has made them necessary. Since "temporary" hardness is not necessarily temporary any more than "permanent" hardness is permanent it is well that we properly define the terms. For the present purpose temporary hardness can be defined as hardness due to the carbonates and bicarbonates of calcium and magnesium. Permanent hardness can be defined as hardness due to the sulphates and chlorides of calcium and magnesium.

It is necessary to point out here that the carbonates, especially calcium carbonate, are largely not soluble in water. While they are said to dissolve in water to produce temporary hardness, they really exist in solution mostly in the bicarbonate form. A bicarbonate in solution may be thought of as a carbonate held in solution by combination with carbon dioxide gas. When carbon dioxide gas is passed into ordinary limewater at first there appears a cloud of calcium carbonate in the water. With the addition of more gas the carbonate is converted into soluble calcium bicarbonate. Magnesium carbonate can be produced from magnesium hydroxide in the same manner. The chemistry involved can be explained by the equations:

$Ca(OH)_2$ Slacked lime (Soluble)	+	CO_2 Carbon dioxide (A gas)	=	$CaCO_3$ Calcium carbonate (Slightly soluble)	+	H_2O Water
$CaCO_3$ Calcium carbonate (Slightly soluble)	+	H_2O Water	+	CO_2 Carbon dioxide (A gas)	=	$Ca(HCO_3)_2$ Calcium bicarbonate (Readily soluble)

If water containing this temporary hardness is heated the hardness is removed, as shown by the equation:

$Ca(HCO_3)_2$ Calcium bicarbonate (Readily soluble)	+ Heat 180-212 deg. F.	=	$CaCO_3$ Calcium carbonate (Slightly soluble)	+	H_2O Water	+ CO_2 Carbon dioxide (A gas)

Observation of this removal of one kind of hardness by heat gave rise to the name temporary hardness.

Why Remove Hardness

That the carbonates of calcium and magnesium require the presence of loosely bound carbon dioxide gas to hold them in solution in water in quantities exceeding more than a few grains to the gallon has been pointed out. The sulphates and chlorides of calcium and magnesium, chiefly to blame for permanent hardness, so

called, are quite soluble in water at all ordinary and even at high temperatures and do not require carbon dioxide gas to make them dissolve. Because they are not bound by gas that can be driven off by heat the constituents of permanent hardness cannot be removed by boiling the water at atmospheric pressure.

In order to contemplate intelligently the need for water treatment in raw water ice making, let us decide first, why hardness forming material should be removed from the water used. The basic reason is found in the habits and experience of the ice consuming public. Ice made from hard water can have just as great a heat absorbing capacity as distilled water ice. It can be as harmless physiologically as the safe water supplies of many of our large cities, yet if it shows signs of hardness forming material, it is not usually marketable because the public, accustomed for many years to the distilled water ice made in the old steam driven ice plant and educated to demand clear ice, is not inclined to change its demands.

When water containing hardness forming salts is frozen the salts do not remain dissolved in the individual ice crystals but are let out of solution at the crystal boundaries. The salts are thus separated from the pure water in the crystals, as by concentration in the cores in freezing cans, and are left spread over the surfaces of the individual crystals, or they are deposited in flakes or nodules among the crystals of pure ice. The salts may be objectionable, therefore, because their presence is apparent (they can be seen) or because they diffuse light passing through the ice or so upset the normal crystal arrangement in the ice as to make it opaque. Different materials have different effect or the same effect in different degrees.

For example, temporary hardness is especially objectionable. The bicarbonates you will recall are really carbonates held in solution by loosely combined carbon dioxide gas. When bicarbonates are frozen out of solution not only is there left carbonate salt mixed with the water crystals but also the gas liberated fills the ice with tiny bubbles making it even more cloudy. Furthermore, when ice containing such material is melted, as in a household refrigerator, the carbon dioxide gas escapes leaving the calcium or magnesium carbonate unable to redissolve in the water. That salt stays, therefore, as an insoluble sediment or scum in the place where the ice melts. This gritty deposit is the precipitated chalk used as the scouring agent in many tooth pastes. The permanent hardness undergoes no change in freezing other than that it separates from the ice to be redissolved when the ice is melted. All forms of permanent hardness render ice cloudy. Magnesium salts are somewhat more objectionable than calcium salts. Sodium salts, although not classed as hardness and not scale forming in boilers, prevent the formation of any but ice that is opaque and that has a characteristic white appearance. They retard freezing and cause the ice to shatter readily. Metallic oxides as the red oxide of iron or the oxide of aluminum impart characteristic colors to ice when they are present in but small quantities.

Treatment

Treatment of water to minimize the effects of dissolved solids in the ice made from the water, may involve (a) removal of dissolved material or reduction of it to its least hurtful forms and (b) control of concentration or segregation of impurities. The latter named method of treatment involves agitation during freezing and perhaps core removal.

Treatment of water that involves change in the chemical nature of impurities is chiefly confined to softening with lime or so called base exchange in a zeolite filter. The removal of bicarbonate material, temporary hardness, with lime is described by the equation:

$Ca(HCO_3)_2$	+	$Ca(OH)_2$	=	$2CaCO_3$	+	$2H_2O$
Calcium bicarbonate (Readily soluble)		Slacked lime		Calcium carbonate (Slightly soluble)		Water

The optimum removal of calcium is governed largely by the limiting solubility of the carbonate which amounts to a few grains to the gallon of water. For temporary hardness due to magnesium the desired action is:

$Mg(HCO_3)_2$	+	$Ca(OH)_2$	=	$CACO_3$	+	$MgCO_3$	+	$2H_2O$
Magnesium bicarbonate (Readily soluble)		Slacked lime		Calcium carbonate (Slightly soluble)		Magnesium carbonate (Soluble)		Water

and

$MgCO_3$	+	$Ca(OH)_2$	=	$CaCO_3$	+	$Mg(OH)_2$
Magnesium carbonate (Soluble)		Slacked lime		Calcium carbonate (Slightly soluble)		Magnesium hydroxide (Insoluble)

It is interesting that double the amount of lime is required for magnesium as is required for calcium. It should be noted that as a softening agent properly applied lime removes bodily temporary hardness substituting nothing therefore. It is significant that in every case of treatment for temporary hardness a precipitate of calcium carbonate is the result and with adequate lime the hardness removal approaches a degree of completion governed by the slight solubility of the calcium carbonate.

While in treating water for use in boilers, change in the form of permanent hardness is of the utmost importance, there is little improvement that can be made when the water is intended for ice making. Usual treatments for sulphates and chlorides of calcium and magnesium involve substitution of sodium for the calcium and magnesium of the salts in order that they be not deposited in boilers. As was pointed out heretofore, sodium salts are nearly as objectionable in ice as are calcium and magnesium salts, hence chemical treatment for permanent hardness is seldom attempted. Because magnesium salts are more objectionable in ice than are calcium it is sometimes desirable to use lime, calcium hydroxide, to force the magnesium into insoluble hydroxide, necessarily leaving a calcium salt in its place. To convert the residual soluble carbonate material into less objectionable sulphate, alum, aluminum sulphate, can be used. Improvement in treating through settling, filtering, or coagulation applied to treated water offers so many possibilities as to be beyond the scope of this discussion.

Zeolite

Zeolite treatment of water, so often a mystery, involves the use of a filter of zeolite mineral. Zeolite contains, among several other elements, sodium, which is responsible for its value. If water containing a scale forming salt of calcium or magnesium is passed over granules of sand-like zeolite the zeolite will exchange its

sodium content for the scale-forming elements in the water.

For example:

$Ca(HCO_3)_2$ Calcium bicarbonate (Temporary hardness)	+	Na_2Ze Sodium zeolite (In filter)	=	CaZe Calcium zeolite (In filter)	+	$2NaHCO_3$ Sodium bicarbonate (Readily soluble)

or

$MgSO_4$ Magnesium sulphate Permanent hardness	+	Na_2Ze Sodium zeolite (In filter)	=	MgZe Magnesium zeolite (In filter)	+	Na_2SO_4 Sodium sulphate (Readily soluble)

It should be observed that zeolite treatment leaves a sodium salt in place of any salt that it removes. In this regard its action is inferior to that of lime for the removal of calcium and magnesium bicarbonates. It does have the virtue of reducing the temporary hardness to zero which lime treatment does not do and it does not produce over treatment. Exhausted zeolite is readily regenerated by passing a solution of ordinary sodium chloride, table salt, through it.

Corrosion

A discourse on water treatment applied to refrigeration requires some mention of water treatment for corrosion control in refrigerating brine. Occurrence of brine corrosion is so closely related to impurities in the raw water used to make up the brine that it is a concern even where water supplies are excellent. Since all brines are likely to be corrosive to some extent, a control of corrosion rate in a manner to slow down or retard the corrosion that does occur is the best assurance of little trouble. A reasonably good indication of the probable rate of corrosion to be expected from a brine is to be found in the effective acidity or effective alkalinity of the brine. The chemist has a term that serves as a measure of effective acidity or alkalinity that is rapidly being recognized in engineering. That term is called the hydrogen-ion concentration or pH value. Without entering into a definition of pH value it is possible to use the term as a quantitative measure of the degree of effective alkalinity or acidity. On the hydrogen-ion scale a pH reading of seven is taken as the pH of pure water which is neither acid nor alkaline. Readings of pH less than seven indicate an active acidity; those greater than seven, as eight, nine or ten, denote an effective alkalinity. The pH range from six to ten is of interest in refrigeration. It has been found that to arrest corrosion the pH value of freezing brine should be about eight (just slightly alkaline) where the brine is in contact with zinc, brass or bronze. Where only iron and steel are in the brine, a pH of nine or ten affords maximum protection. When the pH is too low it can be raised by the addition of an alkali such as caustic soda or lime; when it is too high any acid such as hydrochloric acid, will reduce the alkalinity.

In closing it should be pointed out that the problems of water conditioning have here been dealt with entirely from the ice making standpoint. It is desirable to emphasize the fact that water for ice making and water for boiler use present rather different problems. All mention of the test procedures necessary in the maintenance of suitable water conditions has been omitted in the belief that those operators who appreciate their problems will employ tests commensurate with their needs.

Economical Power for Large Buildings

Convenience and Expediency Should Give Way to Economy in Power Supply. By L. E. Habben*

FOR THE PAST ten years there has been such a decided trend in the direction of super-power, that one will think it a retrograde step to advocate the return of the isolated plant, but I believe it is always well to check up from time to time, to be sure that we are going in the right direction and not thoughtlessly following a beaten track.

A few years ago the road to follow was in many cases one which led to convenience and expediency. I believe that the time has come when we shall be forced to follow the road to economy and to follow it for many years.

Power for large buildings is a subject that is particularly involved, because every building is a distinct problem in itself. From a psychological aspect, the old fashioned plant was undoubtedly dirty and badly laid out, but it should be remembered that the science of designing, and the equipment of the small plant, has progressed along with the design and apparatus of large utility plants.

As to reliability of service, the manufacturers of central station equipment are also the manufacturers of apparatus for the small power plant; the same skill in design and manufacture are used, and the same materials also.

The individual plant must have spare capacity of course, even as the public utility must have spare units so that equipment may be taken out of service for overhauling; the greater reliability of the central station power has yet to be demonstrated, no power company will guarantee to supply power for 24 hr. per day, 365 days per year.

Taking power as an investment, from information obtained from several real estate operators, it is safe to say that few buildings in New York City have paid or will pay for themselves from rentals received inside 20 yr.; a return on the capital invested of 5 per cent.

Savings possible in generating power as against purchasing it are such that there are several companies installing power plant equipment without cost to the owners; the cost of such apparatus being paid for from savings effected. Equipment so purchased is usually paid for in from 3 to 5 yr., a return of from 33⅓ to 20 per cent upon the investment.

Lastly, as an economic measure, some large New York stores report savings due to their power plants of $50,000 to $100,000 per year, the power plants bringing in more profit per sq. ft. of floor space occupied than the sales space of the store above.

It is a peculiar thing but nevertheless true, that in times of prosperity organizations are so busy making money that the power costs of a building are considered of secondary importance and any wasteful features are overlooked; when times are bad there is no money for power plant equipment even though such investment will show the handsome returns on the investment.

*From address before the Management Division of the Real Estate Board of New York, Inc.

POWER PLANT ENGINEERING July 1933

Seasonal Storage Provides-Year Round P

IN SWITZERLAND another important step in electrification has been accomplished by the construction of a large seasonal storage plant: the Oberhasli Hydro-electric Development above Meiringer in the Bernese Oberland. Construction work on the first step of this huge project has been completed recently and the Handeck Generating Station has been turned over to regular operation on October 1, 1932.

The entire development utilizes the precipitations as well as the melting water of a total area of 43 sq. mi., formed mostly by the glaciers of the world renowned "Bernese Oberland". Since the natural flow of water from this area is such, that about 95 per cent of the total annual flow takes place during the six summer months, and only 5 per cent during the six winter months, it was essential to create huge storage basins, in order to have the water collected during the summer available for carrying the high peak of power demand during the winter. Nature offered very favorable conditions, so that it was possible to create two large artificial lakes, the Grimsel Lake (Grimselsee) and the Gelmer Lake (Gelmersee), of a capacity of 3.5 billion and 450 million cubic feet respectively, corresponding to a total storage capacity of 130 million kw.-hr. The Grimsel Lake and the Gelmer Lake are connected with each other by means of a tunnel, thus forming one huge reservoir.

Grimsel Lake has a surface of 27 million square feet and a total length of approximately 3.5 miles. It is formed by two dams, the Seeuferegg Dam and the Spitallamm Dam. The Spitallamm Dam is the outstanding feature of the entire development, due to its tremendous dimensions, and only those familiar with the climatic conditions at an altitude of 6300 ft. above sea level know how to appreciate the difficulties under which construction work had to be going on. Due to the extreme severity of the winter, work could progress only during a few months a year, but nevertheless the dam was completed several months ahead of schedule.

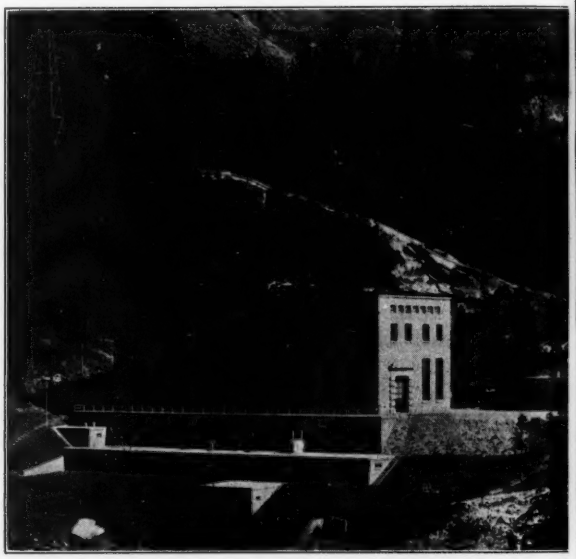


Fig. 1. The Grimsel Lake, 6300 ft. above sea level forms part of the huge Oberhasli hydroelectric development above Meiringen in the Bernese Oberland, Switzerland. This artificial lake with a surface of 27 million sq. ft. has been created by the construction of two dams, the Seeuferegg Dam in the foreground and the Spitallamm Dam in the center of the picture. The new Grimsel Hospice is located between the two dams and it is accessible by means of a motor highway leading across the Seeuferegg Dam.

dPower

Fig. 3. The Innertkirchen Transformer Station, transforming the power delivered by the Handeck Generating Station from 50,000 to 150,000 v. This station is a part of the Oberhasli development shown in Figs. 1 and 2.

Fig. 2. The Handeck Generating Station, 4300 ft. above sea level, forms part of the Oberhasli hydroelectric development. This station with an installed generating capacity of 120,000 hp. is operated by the water accumulated in the Grimsel Lake shown in Fig. 1.

The following figures may give an idea of the dimensions of the Spitallamm Dam, which at the present time is the largest in Europe:

Height above bottom of foundation, 375 ft.
Radius, 295 ft.
Length, 850 ft.
Amount of concrete, 12,000,000 cu. ft.

The water accumulated in the Grimsel Lake is conducted through the horizontal tunnel mentioned above to the Gelmer Lake and from three by means of a pressure line to the Handeck Generating Station. This pressure line consists of steel tubes having a diameter of approximately 8 ft. The line is installed in a tunnel 3700 ft. long, leading from the Gelmer Lake to the Handeck Station, thus covering a difference of altitude of 1750 ft. at a maximum inclination of 72 per cent.

The Handeck Generating Station is equipped with four vertical type units. Each unit is composed of a Pelton type turbine of 30,000 hp. and a generator of 28,000 kv.a. operating at a speed of 500 revolutions per minute and delivering power at 11,000 v.

The problem of delivering the power from the Handeck Station to the load center presented serious difficulties. On account of the large number of avalanches coming down in the neighborhood of the generating station regularly every winter, it was not considered safe to use high tension overhead lines, but it was finally decided that a reliable supply could only be obtained by means of underground cables. Thus a special cable tunnel of 3.1 miles has been built, connecting the generating station with the village of Guttannen. The power is stepped up at the generating station from 11,000 v. to 50,000 v. by means of four 28,000 kv.a. transformers and it is transmitted over four 50,000 v. cable circuits to Guttannen and from there over four 50,000 v. overhead lines to the Innertkirchen Transformer Station. The cable tunnel has been built so large as to permit the circulation of a small electric car which is the only means of communication between the generating station and the villages in the lower part of the valley during the winter season.

At the Innertkirchen Transformer Station the power is stepped up from 50,000 v. to 150,000 v. by means of four water cooled outdoor transformers, and from there it is transferred over two 150,000 v. lines to the consumers in the central part of Switzerland.

As a future extension to this development it is planned to collect the water at the turbine outlets of the Handeck Generating Station and to conduct it by means of a system of tunnels and pipe lines to another generating station which will be built at a site near the present Innertkirchen Transformer Station. Thereby it will be possible to increase the annual production of the development from the present value of 230 million kw.-hr. to approximately 540 million kw-hr.

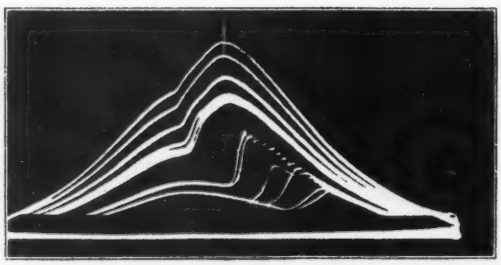
POWER PLANT ENGINEERING July 1933

Combustion Knocks in Diesel Engines

EVERY FACTOR THAT CAUSES A GASOLINE ENGINE TO KNOCK IS LIKELY TO MAKE A DIESEL ENGINE RUN SMOOTHER. BY P. H. SCHWEITZER*

HIGH COMPRESSION RATIO is considered a primary cause of gasoline engine knock, but it has been established that a knocking or rough-going Diesel engine can be made smooth by simply raising its compression ratio. High jacket or cylinder head temperature makes a gasoline engine knock, while it has the opposite effect in a Diesel engine. Tetraethyl lead is a very effective anti-knock for gasoline engines and just as effective pro-knock in Diesel Engines; amylnitrite is the reverse. Fuels of paraffin base consisting mostly of saturated hydrocarbons are the worst knocking fuels in carburetor engines, while they are the smoothest and most desirable fuels for Diesels.

Aromatics and napthenes on the other hand burn roughly in Diesels while they supply the premium fuels for automobiles. Benzol cannot be burned in most Diesel engines, if it does burn it knocks badly. It is the supreme anti-knock fuel for carburetor engines. High temperature of the intake air tends to cause knocking in a gasoline engine while it reduces the knock in a Diesel engine. Investigators have found that ordinarily a smooth-going Diesel engine can be made to knock by throttling the intake air and a rough-going Diesel can be made smooth by supercharging.



OPTICAL INDICATOR DIAGRAMS SHOWING THE EFFECT OF THROTTLING THE INTAKE AIR

The opposite behavior of the compression-ignition engine and spark ignition engine with regard to knocking mystified investigators for some time. Everything seems to be the reverse in Diesel engines, nevertheless common features do exist. Ordinarily both the Diesel and the gasoline engine increase their knocking tendency if the ignition (injection) is advanced. Accurate offset indicator diagrams have shown that in both types of engines knocking is accompanied by a rapid pressure rise. Expressed in crank angles, both a gasoline and a Diesel engine are smooth running if the rate of pressure rise is less than say 30 lb. per deg. crank angle; they are liable to knock if the rate of pressure rise is of the order of 50 lb. per deg. and are almost certain to knock if the rate of pressure rise exceeds 100 lb. per deg. crank angle. Of course the cylinder size and other factors have also influence on the combustion knock.

It is likewise fairly well established that in both types of engines the combustion knock is preceded by the auto-ignition of a portion of the combustible mixture. But here all similarity ends. In a spark ignition engine, when knocking, the rapid pressure rise takes place and the knock occurs at the last part of the combustion. It is the "last gas" to burn which knocks. The first portion of gas ignited by the electric spark certainly could not knock, because only gas adjacent to the spark plug ignites and this is of minute quantity. The propagation of the combustion is a gradual process for a while. The flame front expands and in doing so compresses the unburned portion of the mixture. Finally, a point is reached when the unburned portion is compressed to its self ignition temperature. Then this charge ignites in its entire mass causing a very rapid pressure rise and a sharp knock, frequently called detonation.

PRESSURE RISE

In a Diesel engine on the contrary, the combustion begins with auto-ignition. Here this is the legal method of ignition. But self-ignition need not necessarily cause detonation as thousands of smooth running Diesel engines testify. The determining factor is how much fuel ignites simultaneously. The more fuel ignites in the cylinder practically at the same time, the steeper the resulting pressure rise and the greater the knock.

The Diesel process is frequently described as injecting fuel into pure compressed air, the oil igniting instantaneously when it comes in contact with the highly heated air. If this description were accurate, there would be no combustion knock in Diesel engines, generally speaking. The introduction of the fuel into the cylinder is a gradual process if for no other than for mechanical reasons. The injection extends over a period of 15 to 30 deg., sometimes more, seldom less. During this period the introduction of the fuel is more or less uniform. If the ignition were instantaneous, the rate of pressure rise would follow the rate of fuel injection. One thousand pounds per square inch maximum pressure can be reached from a compression pressure of 450 lb. in 20 deg. with a uniform rate of pressure rise as low as 27.5 lb. per sq. in. per deg.

However, this process is upset by the "ignition lag." The fuel injected does not ignite instantaneously. It takes ordinarily 0.001 to 0.004 sec. in an engine to heat

*Associate Professor of Engineering Research, Pennsylvania State College. From a paper presented before the A.S.M.E.

up the injected oil to its self-ignition temperature. This delay gives the fuel opportunity to accumulate in the cylinder before any ignition occurs as 0.002 sec. corresponds to 12 degree crank angle in a 1000 r.p.m. engine. If the injection is uniform over 20 deg., more than half of the fuel charge accumulates in the cylinder during the ignition lag. This accumulated fuel ignites practically at once as if thousands of spark plugs had set it afire simultaneously. The result is a violent pressure rise and an audible knock. The longer the ignition lag, the steeper the maximum rate of pressure rise and the greater the knock. This fact was confirmed by a linear relation between ignition lag and maximum rate of pressure rise.

Maximum Pressures

Knock or rough-going is frequently associated with high maximum pressures. True, high maximum pressure usually accompanies knock but only incidentally and not necessarily. This is strikingly brought out by throttling the intake air more and more, resulting in louder and louder knock and at the same time lower and lower maximum pressures. However, the optical indicator card shown shows clearly that the rate of pressure rise, i. e., the slope of the pressure curve, increased in spite of the decreasing maximum pressures.

In a Diesel engine it is as a rule the first part of the fuel which knocks, the one delivered during the ignition delay period. The later part of the charge which becomes injected into the flame burns without appreciable lag, as soon as it leaves the spray nozzle. Therefore the later part of the combustion is controlled by the injection and does not cause knocking.

Anti-Knock Diesel Fuels

By far the most important factor with regard to knock is the fuel. Notable advance has been made in the last decade in the production of anti-knock gasolines and a similar problem confronts the Diesel fuel oil technologists. Investigations in various countries are in progress to determine which characteristics make an oil a good Diesel oil and how to obtain them.

There seems to be sufficient evidence that from the knock standpoint it is the ignition quality of the fuel which determines its suitability in Diesel engines. Fuels which are easier to ignite burn smoother. Incidentally the fuels which ignite easier, also start easier and idle better. This is a fortunate circumstance which adds to the importance of the Diesel fuel-knock research.

One of the steps will probably be a standardized method to grade the ignition qualities of Diesel fuels conveniently and yet in such a way that the grading would parallel the actual behavior of the fuel in an engine. Other steps to follow would be in the field of petroleum chemistry which we expect will find ways and means to produce Diesel fuels of high ignition qualities, inexpensively. Petroleum refiners have been making efforts to improve the anti-knock quality of their gasolines. The method used often necessitates wasting a considerable portion of the crude. If the signs are not deceiving, superior Diesel fuels can be made out of this "waste," which may serve even as a dope to blend with less good Diesel fuels.

Although the fuel is the most important factor with regard to Diesel knock, frequently the same fuel will knock in one engine and run smoothly in another. The present day high speed engines are known to increase the knocking tendency of the fuels.

In designing a Diesel engine for smooth running one governing principle should be the shortening of the ignition lag. The problem is essentially one of heat transfer between the hot air and the cold oil drops. The greater part of the ignition lag is the period during which the oil globules are warmed up to their self-ignition temperature. This period increases: 1, with decreasing compression air temperature; 2, with decreased relative velocity between hot air and the globules; 3, with increasing drop size. An effective way to shorten the warming up period in a non-turbulent type of engine is by directing the oil spray so that the smallest oil particles quickly reach the hottest spot in the combustion chamber. In a high turbulence type of engine, the spray should first meet such part of the air stream which has not been chilled very much by flowing with high velocity near cooled surfaces. Such devices as high intake air temperature, high cylinder head temperature and extra high compression ratio have a beneficial effect on the ignition lag. Of course they might be objectionable for other reasons.

Cutting the ignition lag is one way to reduce the knock in a Diesel engine. Another is by reducing the amount of fuel introduced during the ignition lag period. If the rate of injection instead of being uniform during the entire injection period, is low in the beginning and increases later with progressing injection, the portion of the total injected during the delay period will be relatively less. It is most desirable to have injection begin very gradually. Unfortunately in most engines it is the other way. Injection starts with a spurt. The rate of injection is as high or higher in the very beginning as after the ignition lag.

One reason is that the opening of the spray nozzle usually coincides with the arrival of a pressure wave. Another reason is that at the instant the fuel valve is lifted from its seat the fuel pressure gets behind it and exerts an additional push back on the valve stem. This causes a sudden opening of the valve and a high initial rate of discharge. Means for obtaining a low rate of injection during the initial (delay) period are likely to reduce the knocking tendency of the engine, and the more fuel we inject into flame the better off we are.

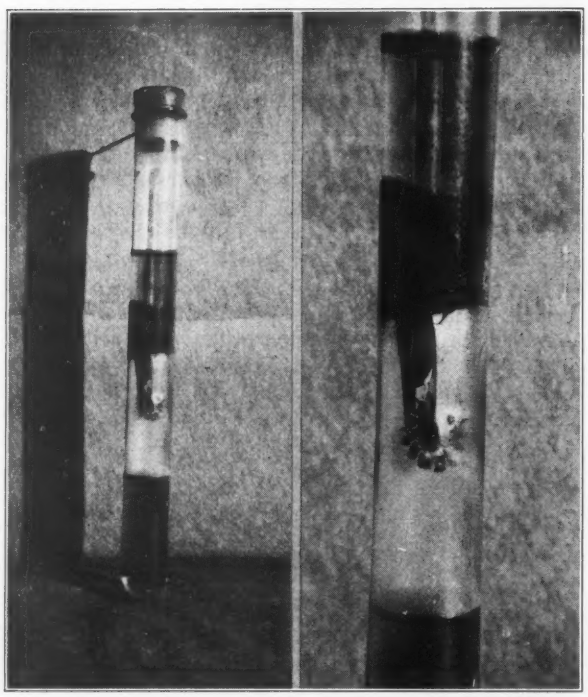
Sand blasting for cleaning tubes of boilers, superheaters and economizers has been used for a number of years at St. Denis and other stations in Paris. A vertical cylindrical sand reservoir of 44 gal. capacity, with conical bottom and adjustable sand valve is mounted on a truck. Sand falls into a jet of compressed air which is supplied at 50 to 80 lb. per sq. in. through an armored rubber hose 1¼ in. diam. and of length up to 30 ft. This delivery pipe ends in a metal nozzle 1/3 in. diam. of mild steel in sections 4.8 in. long which can be quickly replaced as the jet piece must be renewed every 2 hr. The jet is held 10 in. from the part to be cleaned, as shorter distance results in abrasion of the metal. Crushed clinker proved too abrasive so well-dried river sand is used. Ten years experience shows no appreciable damage to metal cleaned and the process is found cheap and effective.

Readers' Conference

Test Tube Turbine

AT A TIME WHEN engineers are striving to create better and larger power plants it is surprising indeed when someone boasts of the smallest one. A power plant within a test tube! That is, one mechanically complete with a boiler, turbine, and condenser all within an ordinary laboratory test tube. There are no fuel charges to worry about as the source of energy is the operator himself. The difference of temperature between that of the operator's hand and that of the room is sufficient to rotate the miniature turbine wheel at a surprisingly high velocity.

The power plant is contained in a test tube one-half inch in diameter and 6 in. long. This tube is partitioned into two equal parts by a rubber stopper, on which is mounted the turbine wheel with the supports along with a small glass tube which acts as the steam jet. The



TWO VIEWS OF THE TEST TUBE TURBINE PLANT
The lower part constitutes the condenser, the upper part the boiler. With a temperature of 95 deg. in the boiler and 50 deg. in the condenser, the turbine operates under a pressure of 0.635 lb. per sq. in.

upper portion of the tube is the boiler and the lower portion is the condenser. The boiler contains about three teaspoonfuls of water which has been colored to accentuate it in the photograph. The tube is sealed after all the air has been extracted. This operation would be rather a difficult one if it were not for the fact that the air could be ejected by the simple expedient of capping the tube after the water in both the boiler and the condenser had been violently boiled for a short time.

Although the temperature difference between that of the operator's hand surrounding the boiler and that of the air surrounding the condenser is the basic source of energy; that in itself does not explain the motion of the turbine wheel. The vapor pressure of the water in the boiler at hand temperature or about 95 deg. F. is .813 lb. per square inch, and the vapor pressure of the water in the condenser at 50 deg. F. is .178 lb. per square inch. This difference of pressure or force is absorbed in accelerating the boiler steam through the jet where it is condensed within the condenser portion of the tube. The steam attains a velocity of 1100 ft. per sec. at the jet and when it impinges the wheel blades.

This process will continue as long as a difference of temperature is maintained, but the temperature of the condensate tends to rise and unless this heat is carried off, the system will attain a condition of equilibrium and the process will cease. When the boiler water is low, the tube can be inverted and on cooling the boiler chamber, the water will be drawn back into the boiler and the power house will again be ready for operation.

Swissvale, Pa. HOWARD S. LONG.

Surplus Power—Availability, Cost and Economic Disposal

THE ARTICLE with the above title by Professor Christie in the May, 1933, issue of Power Plant Engineering appears to have neglected an important phase of the problem of interchange of energy between the private plant and the utility.

Surplus power may be classified as (1) Seasonal, and (2) Daily. Perhaps the commonest example of "dump" energy is the large quantity of water spilled during March, April, and May because of insufficient storage at hydro-electric plants. Obviously, the case where a private hydro plant could supply such energy to a utility system would be so rare as to preclude further discussion, but the advantages of exchanging such energy among the utilities themselves over a "super power" network are just as obvious. Such energy, as Professor Christie points out, is worth but little more than the marginal or incremental fuel costs of the central station, and the subject needs no further consideration here.

The case of a daily supply of "dump" energy presents a new aspect. Some engineers maintain that the industrial plant should receive some credit for relieving the utility of additional plant and transmission line capacity. As Professor Christie states, this is true in the case of a supply of firm power from the industry. In the case of random supplies of surplus power, the the utility has to provide the capacity in plant and transmission system to meet the demands at other periods when surplus power is not available.

What would be the cost of converting dump energy into a particular form of firm power, namely, the

carrying of peak load? This would automatically give such energy considerable capacity value.

For example, consider the case of a utility system with which the writer is familiar. The peak load in a recent year was 88,660 kw. and the top 20,000 kw. of the load duration curve contained 867,000 kw-hr. which requires an average annual use of the peak 20,000 kw. of 43.3 hr., although the base was approximately 350 hr. On the peak days the base of the 20,000 kw. peak was 12 hr., so it follows that about 60 days a year the peak load carrier would be called on.

Assume that the industrial plant has 20,000 kw. of surplus power available at times during the day; in other words, large quantities of steam are generated at high pressure and supplied to the process work through reducing valves, or else generated at the lower pressure, but could by slight additional expense be generated at the higher pressure. The worst possible case would be that all this process steam were unavailable for peak duty. It is also tacitly assumed that the steam requirements of the industrial plant are greatly in excess of the electric requirements. To adapt such a plant would require, let us say, the installation of 20,000 kw. more capacity than the industry requires, and the generation of enough kw-hr. as the utility's peak requires.

In this case the plant would have to generate steam for between 0 to 12 hr. a day for 60 days to carry 867,000 kw-hr. What are these 867,000 kw-hr. and the 20,000 kw. capacity worth to the utility? I do not wish to become involved in the economics of peak load carriers; that subject is amply covered in a paper[1] by Professor Christie and one[2] by the writer. In the latter paper the annual costs to the utility of carrying this peak load were determined and the results are as follows:

	Peak Load Steam Plant	Base Load Steam Plant	Hydraulic Peak Load Plant	Steam Accumulator Plant
Fixed Costs....	$255,000	$345,000	$240,000	$249,000
Additional Operating Costs (Exclusive of				
(Fuel	3,500	10,000	10,000	3,500
Fuel Costs.....	3,530	—126,440*	5,450**	4,810
Total Costs.	$262,030	$228,560	$255,450	$257,310

The cost of this capacity and energy to the industrial company would be merely the fixed charges on the investment in a 20,000-kw. turbo-generator set and switching, regulating and transforming equipment, etc., and the marginal cost of generating the additional steam, or, assuming $50 per kw. as the investment, a water rate of 70 lb. per kw-hr., and a marginal cost of $0.35 per M lb. of steam

20,000 kw × $50 × 15% = $150,000

867,000 kw-hr × 70 lb./kw-hr × $0.35/M lb = 21,241

Total $171,241

The annual net savings over the most economic utility plants are

$228,560 — $171,241 = $57,319

*Negative fuel cost indicates the fuel saving by operating the new base load steam plant in place of the Standard Steam Plant on base loads (80 per cent load factor) and carrying the assumed 20,000 kw. peak load with the available Standard Steam Plant.

**Fuel cost in the hydraulic peak load plant represents the cost of energy for pumping.

The above figures indicate that the governing factor is the annual fixed charges which, I believe, would be less for the industrial plant installation than for the utility plant, because no additional steam generating capacity would be required and probably the only more economical installation for the utility might be a hydraulic peak load carrier, which is greatly limited by existing topographic conditions. The $21,241 item for steam, above, would be reduced in proportion to the availability of surplus steam for process work during peak hours.

Returning to the case of seasonable supplies of surplus power, it is now apparent that it might be economically justifiable to reopen steam and electric generating plants which ordinarily operate only through late spring, summer and early fall for peak duty during November, December, January and February. In certain cases the additional fixed charges due to adaptation for peak load duty would be almost negligible.

The figures used above may be open to question. I believe they are sufficiently accurate for a discussion of this nature, and are, moreover, so variable as to require special attention and estimate on each particular problem. When times again become normal the peak load problem of the public utility will again assume its previous importance, and I believe that solving the problem in conjunction with the one of surplus power can mean a great saving to the utility and a source of additional profit to the industrial plant.

New York, N. Y. ALFRED W. FOX.

[1] "The Peak Load Problems in Steam Power Stations," Trans. A.S.M.E. May-August, 1929; Fuels and Steam Power.

[2] "The Selection of Electrical Peak Load Carriers," the Rochester Engineer, May, 1930.

Synchronizing With The Power Company

I WAS QUITE interested in the recent discussion on synchronizing with outside power companies which appeared in these columns recently since we in our plant have had to do that very thing quite frequently. We have no synchronizing device on our engine so we used the throttle to get the machine in step and also to take the machine off the line.

How much load the engine will carry depends upon the governor setting. It is necessary, therefore, to set the governor for the load desired before the machine is placed on the line. Since the line frequency is nearly perfect, the amount of work that the engine can do is determined entirely by the governor setting. Speeding the engine up means that it will take more load; slowing down means that it will take less.

The idea is to maintain the voltage by means of your rheostat. Never try to run your own regulators on voltage as the power company system is entirely too big for the industrial plant to control.

Many small stations, even though they have synchronizing devices, are placed on and off the line with the throttle or gate valve, if it happens to be a hydraulic plant. In our own plant we have both an engine and a water wheel driven generator, both of which are rated at 150 kw. 60 cycle. We also have an old generator used as a synchronous condenser which is placed across the busses with light loads and run at 100 per cent power factor. At maximum load this unit improves the power factor about 4 per cent on a 1500-kw. load. It is an old machine with an ample amount of copper and

it will take care of 175 kv.a. without trouble. The engine can be operated up to 225 kw. with the condenser on the line whereas without it we would have a hard time to carry 150 kw. W. H. B.

Top-Pull Belts on Pivoted Motor Drives

CONSIDERABLE misunderstanding exists regarding the behavior of drives of this type. The motor of a drive which is bottom-pull sinks back and downward when starting, whereas in a top-pull drive the motor "lifts." It is claimed by some that in both bottom-pull and top-pull drives the motor "lifts" upon starting. A mathematical analysis shows that the two types of drives behave differently. The analyses are supported by behavior in actual practice.

Since the bottom-pull drive has been previously discussed in print we will consider here only the top-pull drive as illustrated in the accompanying sketches where for simplicity both top and bottom belts are horizontal and parallel. The formula for this drive is:

$$TH + B\,h = W\,L$$

Where T = Total tension in the top belt in pounds.
H = Lever arm of the top belt in inches.
B = Total tension of bottom belt in pounds.
h = Lever arm of bottom belt in inches.
W = Total weight of motor and base in pounds.
L = Lever arm of the weight, W.

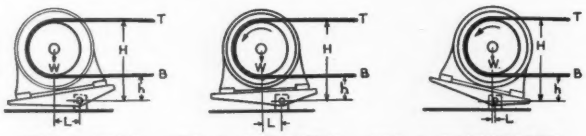


FIG. 1. IDLE FIG. 2. STARTING FIG. 3. DANGEROUS

For example, if we have a motor and base weighing a total of 1000 lb. and if it is so arranged that when idle the distance L is 5 in. as shown in Fig. 1 and if the diameter of the pulley is 20 in., the lever arm h being 5 in., the lever arm H will of course be 25 in. It will be found that when idle the tensions T and B will be 167 lb. Substituted in the above equation we have:

$$(167 \times 25) + (167 \times 5) = 1000 \times 5$$

Upon starting the immediate effect of the rotation of the motor pulley is to increase the tension T and this will cause the motor to "lift" as shown in Fig. 2. In other words, the lever arm L will become less. Let us assume that L will become 4½ in. This means that the tension B will reduce. In other words, the bottom side of the belt will become slack. For convenience let us say that the tension B will drop to zero. Then, substituting in our formula we have this:—

$$(T \times 25) + (0 \times 5) = 1000 \times 4\tfrac{1}{2}$$
whence $25\,T = 4500$
and $T = 180$ lb.

In other words, owing to the fact that the bottom side B becomes slack, and even though the lever arm L becomes less, there is an actual increase in the tension in the pulling side T. This increase may be necessary in order to take care of the starting load.

Obviously with a drive of this sort it is important to exercise caution in making preliminary computations so that the motor will not be pulled over to an extreme position as shown in Fig. 3. When lever arm L is reduced to only 1 in., say, it is obvious that the pulling capacity of the motor is reduced in direct proportion to that reduction because then our formula tells us that

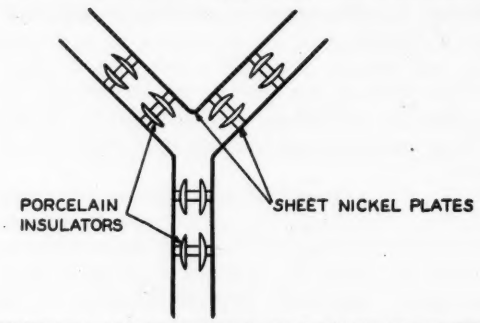
$$(T \times 25) + (0 \times 5) = 1000 \times 1$$
whence $25T = 1000$
and $T = 40$ lb.

To prevent a situation such as illustrated in Fig. 3 weights, stops, or auxiliary springs may be employed.
Newark, N. J. W. F. SCHAPHORST.

Prevention of System Speed Changes

An electric power system in Mexico operating a station of 50,000 kw. capacity near Orizaba furnished energy to an electric railroad system which, due to long heavy grades, made use of regenerative breaking. During periods of light load and on Sundays the operation of a train down a continuous grade exceeding 10 miles tended to carry the system load and speed up the system frequency considerably, as the base load was low. All energy was generated by hydraulic turbine driven units. To control this condition the following scheme was used.

A three phase water rheostat operating at 4600 v. between plates was located adjacent to the station in a concrete basin through which fresh water flowed continuously. The rheostat, which consisted of three sheet nickel plates, was shaped in the form of a Y as shown in the illustration with porcelain insulating spacers connecting the plates so that the whole assembly was rigid; the group was attached to one end of an I beam section counterweighted and pivoted on a knife edge. The plates were lowered or raised automatically by means of a mechanism consisting of a standard hydraulic turbine governor and a synchronous motor driving it; the governor was arranged with two sets of electrical contacts set to close two magnetic clutch circuits at predetermined speeds above and below the normal value. The governor being driven directly by the synchronous motor tended to respond at once to any change in the system frequency. The motor also drove a shaft with the two magnetic clutches mounted on it which in turn raised or lowered the plates through a simple mechanical connection to the beam. The motor operated at 3600 r.p.m. so was very sensitive to any change in frequency and the rheostat operated very easily without hunting. It was stated by the manufacturer that the foregoing method was used rather than an electrical method by means of a contact-making meter, due to the fact that the decrease or increase in speed occured a perceptible interval after any load change so that there was less tendency to hunt.



SHOWING ARRANGEMENT OF PLATES IN WATER RHEOSTAT

Brooklyn, N. Y. C. O. VON DANNENBERG.

Maintenance of Feedwater Regulators

AN ITEM came up recently in a boiler room which up to that time had been given little thought as to being a possible cause of trouble. This concerned the maintenance of the expansion tube type of feedwater regulator. A number of these had been in service in the plant referred to for many years with excellent results and practically no attention being required. It had been noticed, however, that from time to time a slight adjustment in the tension nuts at the end of the thermostatic tube had been required. This adjustment had always been in the same direction. At last these nuts had reached their limit in travel in this direction and it was decided to find the cause of this.

To make an examination, the expansion tube was dismantled and it was discovered that while the inside diameter of the tube was normally ¾ in., it was choked with a hard layer of scale for its entire length. This scale was so thick as to leave a hole through the tube of only about ¼ in. in diameter. It was then easy to see that due to the poor heat transfer rate of the scale that the atmospheric temperature had more effect on the metal of the thermostatic tube than the steam and water within. This acted then exactly as though high water existed in the boiler and the adjusting nuts would be turned back more and more to counteract the effects of the scale.

Using a lathe the tube was carefully bored out to its original diameter with a boring tool made up especially for this purpose. After this had been done the regulator was reassembled and no further difficulty was had. It would probably be the best policy to install a new tube in many cases rather to go to the expense of making up a tool for one tube. However in the case mentioned a number of these regulators were in service and it was anticipated that further use for this tool would be had in the near future.

Milford, N. J. HARRY M. SPRING.

Glass Piping

IN CONNECTION with H. C. Moffett's article on nonferrous substances used in piping construction I wish to bring out the use of glass in piping. Glass and porcelain valves or cocks always had some limited use in chemical plants, but not so the straight glass tube. On account of the difficulty in making leak proof end connections to glass or porcelain fittings, glass tubes are normally used only for liquid gages, etc., where visibility is desired. In the cases referred to here pyrex glass tubes were used in a cooling coil made up in banks 30 to 40 tubes high. The tubes were 2 in. diameter ⅛ in. wall, 20 ft. long each. The 180 deg. return bends connecting adjacent tubes were made of cast iron. As it was the cooling sea water trickling over the coils, and not the fluids inside of the coils that was corrosive, this arrangement was satisfactory. The only objection to the use of glass in cooling coils is its low heat transfer coefficient.

By the use of specially designed metallic glazed elbows and tees provided with union ends or packing glands with suitable packing there is no reason why glass pipe lines could not be used for handling highly corrosive fluids at moderate temperatures and pressures.

Mr. Moffett mentions that when aluminum seamless tubing is used for piping the connecting fittings are made of cast aluminum. With flanged piping this is not necessary as tees could be formed by welding or brazing necks on the straight tubes while elbow turns of almost any radius of curvature could be formed by cutting the tube on a bias at 45 deg. and welding two together, or cutting the tube at 22½ deg. welding three together, or at 15 deg. welding four together, etc. The welding, or brazing of aluminum is now being done very satisfactorily.

Pittsburgh, Pa. BERNARD KRAMER.

Overloaded Turbine

SOME TIME AGO we had difficulty in securing sufficient pressure for an adequate boiler feed supply on six 350-hp., 140 lb. gage Stirling boilers. The boiler feed pump, a two stage centrifugal operated against 160 lb. gage, with about 2 ft. head on the suction. It is direct connected to a tangential flow type turbine under 140 lb. steam and from five to 20 lb. exhaust, controlled by a compensating pressure governor.

Even with both auxiliary nozzles open 140 lb. steam and not over 15 lb. back pressure, a heavy surge on the boilers resulted in the loss of feed water pressure, making it necessary to start an auxiliary pump. Plainly enough the turbine was overloaded, because a tachometer gave the speed as well below maximum.

When the pump was dismantled it was discovered that larger impellers had been substituted, apparently in the hope of increasing the pressure. The old impellers were found and by comparison proved to be the same except for a ten per cent difference in diameter.

Taking into consideration the speed attained with the larger impellers and that attainable efficiently with the turbine without overload, ten per cent more was turned from the diameters of the old runners. These were replaced in the pump, and the pump assembled, with no other changes.

The unit has been in service for several months of continuous duty and without failure or delay except for an occasional packing. It furnishes an ample supply of feedwater at all times with both auxiliary nozzles closed and the speed well below the safety governor.

Trials have proved there are ten pounds reserve pressure to be had, if required, before the power demanded by the pump balance that available from the turbine.

Windsor, Colo. J. R. GOODNER.

Editor's Note. Because of the relation of head, capacity, speed and horsepower of centrifugal pumps it is not wise to make alterations without consulting the manufacturers regarding the impeller characteristic.

Knot Kink

TO PREVENT a knot from untying, dip it in glue. It has been my experience that when knotting the end of a rope to prevent fraying, the knot frequently "slips out" due to the slipperiness and stiffness of the rope, especially if it is a new one. Make the knot as hard and tight as possible, dip in glue, allow to dry, and, like Alexander the Great, you will be obliged to cut it if you want to untie it.

Newark, N. J. W. F. SCHAPHORST.

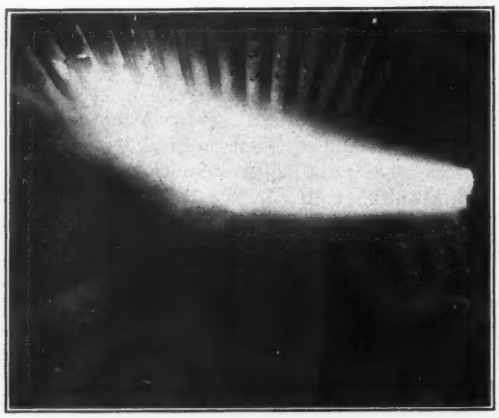
Plant Operation Problems

Crank Case Oil

WE HAVE a great deal of automobile crank case oil we would like to burn under our boilers but are at a loss to understand how to handle it in conjunction with our stokers. The boilers, 300-hp. Wickes vertical water tube, are set very close together and the stokers are in the way in front so the only place available for the burner would be the peepholes in the firedoors. These holes are about 3½ in. in dia. We have no compressed air in the plant and would have to use steam for atomization. We would appreciate your advice as to what can be done along this line. We do not, of course, expect to carry a load on the oil but simply use this as a method of getting rid of the oil which is becoming a nuisance.

A. R. W.

A. Inquiries among the oil burner companies show that the oil drained from automobile crank cases is being used successfully in many places. Many of these installations are in garages in conjunction with low pressure or hot water heating systems, usually with air atomization although there are a number of installations in power boilers using steam atomization. A definite answer and recommendations would require detailed knowledge of the size and type and arrangement of the furnace and stoker and apparently it would be practical



PAGE BURNER SHOWING CRANK CASE OIL FLAME IN THE FURNACE

and possible to get an oil burner which could be arranged to fire through the 3½ in. hole in the door.

The accompanying photograph shows an oil burner being operated with crank case oil. We are quoting in detail from a letter describing this installation, as it has a bearing upon another phase of power plant operation which is rather interesting:

"I have been doing this in connection with stoker firing for some time and I am enclosing a photograph of one of my oil burners flame when burning crank case oil. It is shown in connection with a 300-hp. B. & W. boiler equipped with a Murphy furnace. This burner will produce 200 b.hp. We also have this equipment installed in connection with a 100-hp. boiler fired by a Coxe anthracite chain grate stoker. Two such oil burners are used and they are able to kindle a fire with the oil burners and anthracite coal and raise steam to 350 lb. boiler pressure in a space of 30 min.

"We are in a position to guarantee the result on oil burning equipment that is capable of burning crank case oil and in fact, the burners are suitable for a wide variation in the grade of fuel. Steam atomization is very satisfactory and we have a number of installations using steam only, in fact the Bremo Bluff installation is so equipped.

"Oil burning equipment is available that will give them any reasonable hp. they desire in connection with their stoker firing and will kindle their stoker fires in less time than it takes to lay the kindling wood in the furnace preparatory to lighting a stoker fire in a common way. It requires from six to 10 min. to completely kindle the fire on a stoker suitable for 750 hp. burning bituminous coal. In fact, we often accomplish this in five minutes.

"Several installations have been made in Rochester burning crank case drainings in connection with powdered coal fired furnaces and one with stoker fired furnace on bituminous coal. The beauty of these installations is the extremely small cost to install the equipment and its unusual durability in service."

If readers have had experience with the installation of burners for handling crank case oil, or for kindling fires on stokers, we would like to hear from them. If possible, the letter should be accompanied by a sketch showing the arrangement and dimensions of the furnace and burner. Replies that are suitable for publication will be used as space permits.

Waterproofing Tank Surface

WHAT KIND of paint will give the best service when used to paint the inside of a cold water storage tank?

E. O. L.

A. The question of a suitable paint for under-water protection of metallic surfaces is one that is not easily answered. Paints are not so satisfactory when used under water as when used for protection against atmospheric corrosion. While a number of special paints have been developed for hot water service, for general use in contact with water at normal temperatures red lead of good quality applied to a carefully cleaned dry surface has given the best all around service.

In a test in Boston, seventeen different kinds of paint, applied in vertical strips to a standpipe holding Boston water indicated that paints made up of red lead or red oxide of lead were most protective.

In preparing the metal surface for painting, the surface should be freed from all mill scale and rust by pickling, sandblasting or by scratchblasting. If grease or oil is present this should be removed either by boiling in a 5 per cent solution of soda ash or caustic soda or by washing with solvent naphtha.

Evaporation Formula

WILL YOU please tell me if the following formula for evaporation is correct? The formula is W = (C × H × 0.75) ÷ 1100, where W = weight of steam generated in pounds per hour; H = B.t.u. per pound of coal, and C = pounds of coal burned per hour.

L. M.

A. Fundamentally the equation is correct although with the two constants as included it will give you the correct answer for two conditions only, that is, for a boiler efficiency of 75 per cent and a steam pressure and temperature and feedwater temperature such that the total heat added by the boiler to each pound of steam is equal to 1100 B.t.u. To make the formula general it could be written,

$$W = C \times H \times E \div S$$

where

E = Boiler efficiency expressed as a fraction
S = Heat added by the boiler per pound of steam

To determine S exactly for any given condition it will be necessary to know the pressure and temperature of the steam and the temperature of the feedwater entering the boiler.

The total heat content of steam above 32 deg. F. can be found from the steam tables. For instance, at 125 lb. ga. the heat content of saturated steam is 1192 B.t.u. per lb. Not all of this head is added in the boiler, however. If the feedwater enters the boiler at 124 deg. F. it already has a heat content of 124 minus 32 or 92 B.t.u. per lb. The heat added by the boiler would then be 1192 minus 92 or 1100 B.t.u., as the constant given in your formula.

In order to make steam, heat is added to the water in two or three stages. First, the water is heated to the boiling point; then the latent heat is added while the water is being vaporized at constant temperature; then (if superheated) more heat is added in the superheater also at gradually increasing temperature. This is shown on the accompanying chart where the temperature in degrees Fahrenheit is plotted against the heat content in B.t.u. per pound. Assume that water enters the boiler at A′ at 125 deg. F. with a heat content of 92 B.t.u. It is heated up to C, the saturation temperature, and then vaporized to point C′, where the heat content is 1192. Obviously the heat added by the boiler the heat at C′ minus the heat at A′ or 1192 minus 92 = 1100 deg. as above. If the feedwater enters the boiler at 200 deg. F. as at A, the heat content would have been 168 and the boiler would have only had to add 1192 minus 168 or 1024 B.t.u. to make a pound of dry steam. That is, the feedwater heater saved the boiler the amount of heat indicated by the cross hatched area under A′A.

A study of this chart explains considerable about the process by which evaporation takes place. The line AG is usually known as the 'liquid line' and the line GF′B′ as the vapor line. Taking any particular case, such as for instance 67 lb. pressure, feedwater at 32 deg. F. would be heated up to the point B by the boiler before it would begin to boil. Latent heat would then be added along the line BB′ and when the water was entirely evaporated additional heat would cause superheating along the line B′ and B″. Diagonal lines marked 20, 40, 60 and 80 between the liquid line and vapor line represent the quality of the steam at that particular point that is the proportion of the water that has been turned to steam. As the pressure is increased, for instance, from 67 lb. at BB″ to 680 lb. at EE′, it will be noticed that the latent heat represented by the length

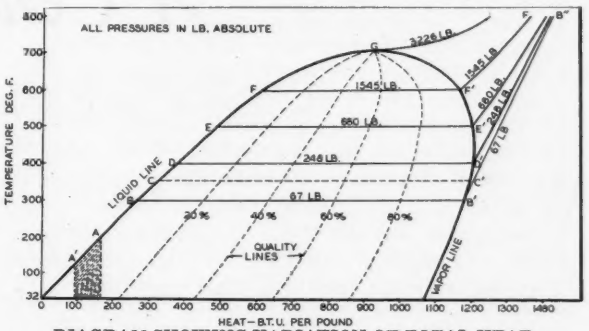


DIAGRAM SHOWING VARIATION OF TOTAL HEAT WITH TEMPERATURE

of the above lines decreases. This decrease in latent heat continues to point G, or the critical condition, the water vaporizes without boiling. This is at a temperature of 706.1 deg. F. and 3226 lb. pressure where the density of water and the density of steam are the same. It is at this pressure that the Benson boiler operates.

Another interesting point is that the total heat of steam from point G gradually increases to a little over 1200 B.t.u. and about 400 lb. and then decreases so that steam at 67 lb. has a greater total heat than steam at 1545 lb. as shown by the curve.

Engine or turbine efficiency is generally considered to be increased as the superheat is increased, that is, the larger the proportion of superheat to total heat the higher the efficiency. Looking at the temperature heat curve it might therefore, be expected that 67 lb. steam with superheat represented from B′ to B″ would give a higher efficiency than, for instance, say, 1545 lb. steam with a superheat of only from F′ to F. This is not true, however, because of excessive moisture in the turbine exhaust for low initial pressure. The expansion line through a turbine can not readily be shown on a chart of this kind and is best shown either by a temperature-entropy chart or Mollier diagram. The latter is explained on page 1095 of the Nov. 15, 1931 issue.

Keying Up Engines

1. Which way should a crank pin stand to key up on a horizontal engine?

2. What are the sharp edges on a piston ring for?

O. E.

A. The crank pin should stand at the top or bottom position when being keyed up, because as the pin has a tendency to wear oblong, the take-up in the vertical position will be the minimum and prevent the box from being too tight.

2. There should be no sharp edges on piston rings. The edges should be either beveled or rounded off so as to allow the lubricating oil film to form on the ring. When piston rings have sharp edges, they have a tendency to scrape the oil off without giving the proper lubrication to the cylinder. (Answered by Henrik Greger, chief engineer of the Hooven, Owens, Rentschler Co., Hamilton, Ohio.)

Engineering Week at *A Century of Progress*

JUNE CONVENTIONS BRING TO CHICAGO THE GREATEST ARRAY OF SCIENTIFIC AND ENGINEERING TALENT EVER GATHERED

WITH A CENTURY OF PROGRESS, dedicated to science and scientific achievement, as the shrine, Chicago is this year the Mecca for scientists and engineers of every nation. Activities will extend throughout the summer although June is the most important month, some two score conventions centering around special celebrations at the Fair, such as: Electric Day, June 7; Water Works Day, June 16; Coal Day, June 17; Scientists' Day, June 19; and Engineers' Day, June 28.

To engineers the last week in June merited particular attention, as a score of societies coöperated with the Western Society of Engineers in organizing an Engineers' Week worthy of the name. Most of them agreed to suspend individual programs to take part in the Engineers' Day program, Wednesday, June 28, at the Fair Grounds when arranged, among other things, for the formal awarding of the Guggenheim Medal to Juan De La Cierva for his invention of the Autogiro. In the evening all societies arranged to participate in a joint banquet at the Stevens Hotel, to hear E. J. Kelly, Mayor of Chicago, E. J. Mahren of the Portland Cement Association and Karl T. Compton, president of Massachusetts Institute of Technology.

The convention season was opened by the first annual convention of the newly formed Edison Electric Institute which met June 5-8 at the Palmer House. This was followed by the National Warm Air Heating Association meeting, June 6-8 at the Stevens Hotel; the American Oil Burner Association, June 12-16 at the Stevens Hotel; the American Institute of Chemical Engineers, June 14-16 at the Medinah Athletic Club and the American Water Work Association, June 12-16 at the Sherman Hotel.

On June 12 this latter association joined with the Western Society of Engineers, American Society of Mechanical Engineers; American Society of Civil Engi-

LIST OF SOCIETY AND ASSOCIATION MEETINGS IN CHICAGO DURING THE MONTH OF JUNE

NAME OF SOCIETY	DATE OF MEETING	PLACE OF MEETING
American Assn. for the Advancement of Science	June 19-30	Stevens Hotel
American Assn. of Engineers	June 28-30	LaSalle Hotel
American Ceramic Society	June 25-30	Stevens Hotel
American Inst. of Electrical Engineers	June 26-30	Edgewater Beach Hotel
American Inst. of Mining & Metallurgical Engineers	June 26-30	Stevens Hotel
American Foundrymen's Assn.	June 19-23	Stevens Hotel
American Institute of Chemical Engineers	June 14-16	Medinah Athletic Club
American Oil Burner Assn.	June 12-16	Stevens Hotel
American Society of Civil Engineers	June 27-30	Palmer House
American Society of Mechanical Engineers	June 25-30	Palmer House
American Society of Municipal Engineers	June 25-30	Stevens Hotel
American Society of Refrigerating Engineers	June 26-28	Sherman Hotel
American Society for Testing Materials	June 26-30	Stevens Hotel
American Water Works Assn.	June 12-16	Hotel Sherman
American Welding Society	June 29	Congress Hotel
Econometric Society	June 30	Palmer House
Edison Electric Institute	June 5-8	Palmer House
Institute of Radio Engineers	June 25-30	Sherman Hotel
Int. Union of Pure & Applied Science	June 24	University of Chicago
Midwest Engineering & Power Exposition	June 27-29	Stevens Hotel
National Council of State Boards of Engineering Examiners	June 26-28	Stevens Hotel
National District Heating Assn.	June 27-30	Palmer House
National Industrial Advertisers Assn.	June 26-28	Medinah Athletic Club
Smoke Prevention Association	June 20-23	LaSalle Hotel
Society of Industrial Engineers	June 27-30	Stevens Hotel
Society for Promotion of Engineering Education	June 26-30	Stevens Hotel
Western Society of Engineers	June 28	Stevens Hotel

neers; American Water Works Association, and Swedish Engineers Club in special ceremonies at the historic Chicago Avenue Water Tower to honor E. J. Chesbrough, DeWitt C. Cregier and John Ericson, three men who played an important part in developing the Chicago water system.

With the convening of the American Association for the Advancement of Science and affiliated societies at the Stevens Hotel, June 19, activities began in earnest, the simultaneous and joint sessions of the various societies being so interrelated that continuity of a report cannot be maintained. In general pure science papers were grouped in the week of June 18 and applied science and engineering the week of June 25. As both Scientists' Week and Engineers' Week occur after this is written the events mentioned must be considered as a summary of schheduled events taken from the latest available programs.

Evening and joint sessions over this two weeks' period were arranged to be of wide general interest so as to appeal to the general society memberships. Some forty odd foreign guests appearing on the various programs are to be honored by a reception given by the Century of Progress in the Hall of Science, June 19 and again on June 22 by the societies themselves at a banquet in the Stevens Hotel.

On Wednesday evening, June 21, the Physics Section of the A.A.A.S. met to hear Dr. F. W. Aston of England on "The Story of Isotopes" and Dr. R. A. Milliken of California on "New Light on Nuclear Physics." Tuesday, June 27, Dr. A. P. M. Fleming of England addressed section M of the A.A.A.S. on "The Development of Engineering in the Last One Hundred Years" and on June 27 at another joint session Dr. H. J. Gough, also of England, delivers the A.S.T.M. Edgar Marburg Lecture on "The Crystalline Structure in Relation to Failure of Metals, Especially by Fatigue." Engineers' Day, June 28, has already been mentioned.

Under the auspices of the American Society of Military Engineers a joint engineering luncheon was arranged for Thursday, June 29, in honor of General Lyle Brown, chief of the Corps of Engineers. Fundamental problems of mutual interest to scientific economists and engineers was scheduled for Friday, June 30, at a joint session by the Econometric Society, A.S.M.E., A.I.E.E., A.S.C.E. and A.S.T.M.

By way of anniversaries, the Society for the Promotion of Engineering Education will celebrate its fortieth anniversary, having been formed on the occasion of the Fair of 1893. It will be recalled that the first Chicago World's Fair was an engineering event of world wide importance and the W.S.E., who are acting as hosts to the engineers of the world, are using as the official register the same book used in 1893. The names in this old book read like an Honor Roll of Engineering. It will be available for inspection and registration in the offices of the society in the Engineering Building throughout the summer.

American Institute of Electrical Engineers

At the first session of the A.I.E.E. the Lamme Medal is to be presented to Dr. Edward Weston, other sessions being devoted to protective devices, instruments, transmission and distribution. Design features of the Port Washington Station and the Beauharnois Development will be described, while in a joint meeting with the A.S.M.E. and A.I.C.E., a resume of the engineering reports on the St. Lawrence waterway development will be given. Sessions on the last day cover electrical machinery, welding and electrophysics in the morning and joint meetings with the Econometric Society, A.S.M.E., A.I.C.E., and A.S.T.M. Engineers' Day members of the A.I.E.E. participate in the joint activities at the Fair Grounds and in the banquet at the Stevens.

American Society of Mechanical Engineers

By far the most elaborate and extensive program of the month was arranged for by the A.S.M.E., some 147 papers being scheduled at 43 sessions crowded into five days. Sessions extended through the mornings, afternoons and evenings, sometimes as many as seven meetings being held simultaneously. With the exception of two general sessions with the A.I.C.E. and one with the A.A.A.S., the first two days are devoted to various sections within the society, with the last three days largely devoted to joint activities, with the A.I.C.E., A.I.E.E., A.A.A.S. and A.S.T.M., Engineers' Day, Wednesday, June 28th, being taken up with the special Fair Grounds program and joint dinner at the Stevens Hotel.

American Society of Refrigeration Engineers

Space cooling for both domestic and residential purposes occupies a considerable portion of the A.S.R.E. program, the self-contained units for this service being given particular attention, while thermodynamics of SO_2, CO_2 and solid absorbents are covered by three papers and ensuing discussion in another session. In the general engineering session three papers should create particular interest. They are: Evolution of Condenser Design by H. C. Guild; Fluid Flow in Pipes by H. J. Macintire and Natural Gas Engines in Refrigeration Plants by C. T. Baker.

American Society for Testing Materials

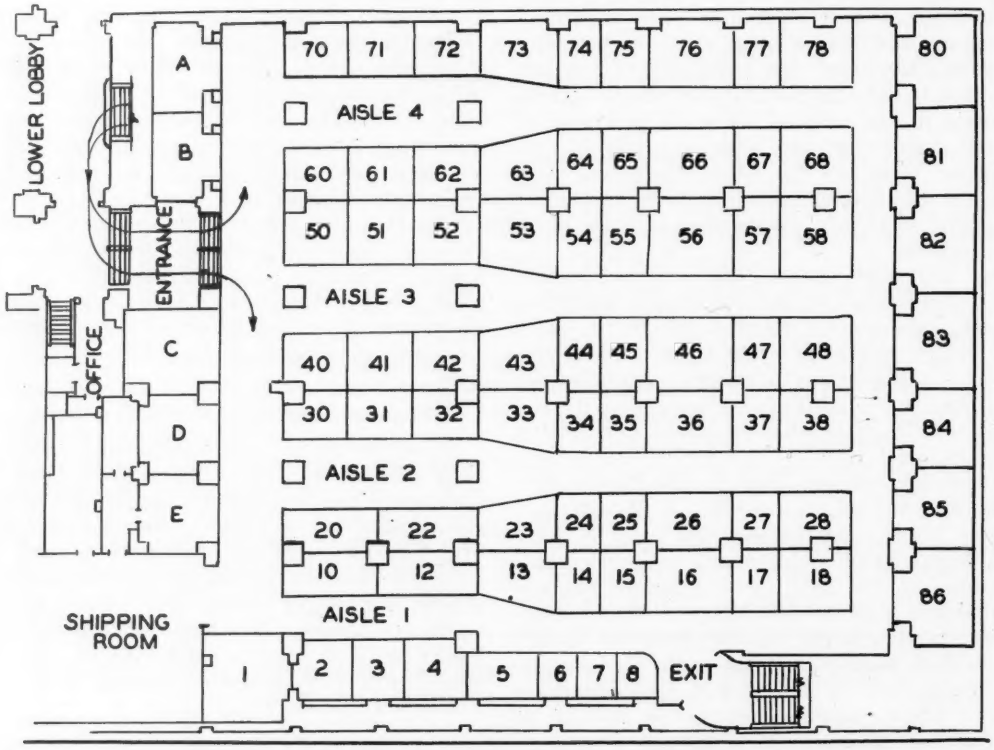
At the thirty-sixth Annual Meeting of the A.S.T.M., the Eighth Edgar Marburg Lecture will be presented by Dr. H. E. Gough, Superintendent of the Engineering Department of the National Physical Laboratory of England. The subject of the lecture is the crystalline structure in relation to the failure of metals especially by fatigue. Fourteen sessions are planned but in arranging the program of the meeting consideration was given to the unusual number of activities running concurrently in Chicago. Joint meetings with other societies include the American Foundry Men's Association and a joint session on economics at the Palmer House with the Econometric Society, A.S.M.E., A.I.C.E. and A.I.E.E.

National District Heating Association

Aside from the usual committee reports, the N.D.H.A. program has a number of unusually interesting papers dealing primarily with cost and construction of distribution systems and station operation. Among the papers of more immediate interest to the power engineer are: Line Losses and Delivery of Superheated Steam by P. F. Helm; Heating Effect of Underground Steam Lines by W. A. Herr; Distribution System in Washington, D. C., by A. J. Slade; Bituminous Coal Rates by Chas. O'Neill; Gas Washing for Sulphur Dioxide by H. F. Johnstone; Feedwater Treatment by S. T. Powell; Competitive Fuels by George Orrok, Jr., and By-product Generating Cycles by R. G. Felger.

Midwest Engineering and Power Exposition

Stevens Hotel Exhibition Hall—June 27-29
Directory of Exhibitors and Booths



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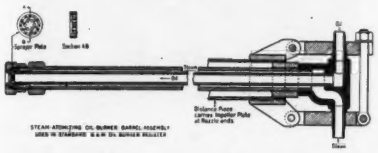
New Equipment

New B & W Steam Atomizing Burner

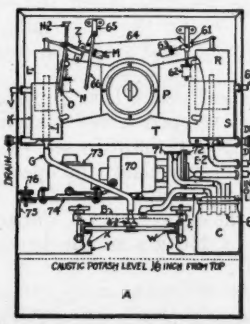
FOR HANDLING fuels such as heavy oil, tar, pitch, and acid sludge, as available in quantities in petroleum refineries, The Babcock & Wilcox Co. has developed a new steam-atomizing burner. Steam is admitted to the annular space around the central fuel barrel and is projected across each outgoing stream of fuel



at the nozzle plate, thus effecting complete atomization and resulting in a short turbulent flame when used with the standard B. & W. burner register. A single nozzle plate is used for all capacities from the maximum to minimum ratings, variations in capacity being accomplished by varying the fuel and steam pressures.

Defender Co_2 Recorders

SEVERAL NEW MODELS of automatic one, two and three pen CO_2 recorders were recently announced by the Defender Automatic Regultor Co., St. Louis, Mo. The illustration shows two pen Type N, which differs from the single pen model by the addition of the draft pen movement shown at the upper right hand corner. The three pen models have in addition a flue gas



thermometer mounted at the top, this instrument giving a complete CO_2, flue gas temperature and draft record on a single chart. Type M differs from type N only in the size of the motor and gas pump, both instruments being in the same size case and interchangeable.

Portable models are also built in the one, two and three pen type with a hand Orsat for checking, rubber tubing, gas filter, etc., packed in a compartment at the back of the case so that the unit is complete and can be carried in one hand. The portable units are 16 in. high, 12¼ in. wide and 7½ in. thick and weigh from 30 to 35 lb. depending upon the model. One and two pen models use an 8 in. round chart, the three pen model a 10 in. chart.

G-E Develops Oil-Resisting, Heat-Resisting Cable

A NEW CABLE INSULATED with Glyptal-treated cloth and capable of resisting oil and withstanding high temperatures has been developed by the General Electric Co. This new cable is also characterized by unusual flexibility and toughness.

Insulating material known as Glyptal is a synthetic resin, produced from phthalic anhydride and glycerine, which is unaffected by mineral oil. Samples of cable insulated with Glyptal-treated cloth have been exposed to temperatures of 100 deg. C. for periods of three to four months without showing appreciable deterioration.

Cable insulated with Glyptal-treated cloth can be used advantageously for low- and medium-voltage leads, apparatus cable, transformer leads, leads for coils and control devices, or wherever an oil-resisting, heat-resisting cable is required.

Rubber Lined Valve

DESIGNED for handling corrosive and abrasive fluids under conditions of fairly high pressure, pulsating pressure, throttling or suction, a new rubber-lined valve of simple, rugged design known as the Vulcalock valve is announced by The B. F. Goodrich Rubber Co., Akron, O. The new valve may be lined with any of the standard Goodrich Acid-seal rubber compounds, hard or soft, depending upon conditions of service. Action of the valve does not depend upon a flexible diaphragm. The resilient, rounded disc which snaps over a circular plate at the lower end of the stem provides an absolute seal when brought into contact with the molded rubber-covered seat. Both disc and ring are simple, inexpensive, easily replaceable parts. A steady, uniform flow with positive shutoff is obtained under severe operating conditions.

Corrosive or abrasive materials come in contact only with rubber especially designed to resist their deteriorating action. On sizes up to and including 6 inch, there is no restriction of flow through the seat ring. Can be quickly changed from a straightway to angle valve or vice versa by removing body bolts, reversing the lower body section and replacing the bolts. When valve is in wide open position, back of resilient disc seals off stuffing box, which can be repacked while valve is under pressure.

THE MILDON ENGINEERING CO., Inc., 25 Broadway, New York City, has developed a furnace glaze or vitrified coating for refractory walls, marketed under the trade name of Fire-Kote. It is claimed that Fire-Kote, which does not contain silicate of soda, fuses progressively between 1200 and about 2800 deg. F. and does not refuse or run at much higher temperatures having been tested above 3400 deg. It becomes an integral part of the refractory and prolongs the refractory life.

Combination Instrument

THE FOXBORO CO., Foxboro, Mass., has recently developed an instrument for recording and controlling pressure, and recording flow. The pressure controlling mechanism is of the Stabilog type, which permits full-floating valve action. The flow meter construction is identical with the latest developments in flow meter design as made by that company. A number of these instruments have found application on gas pressure regulation where flow measurement is essential, such as in back pressure regulation with metering of tail gas from oil refining processes, and on steam lines and fuel gas lines where pressure reduction is important and metering essential. The instrument is equally adaptable to pressure regulation and metering of liquids and is used on water lines, brine lines and similar services.

Plibrico Observation Port

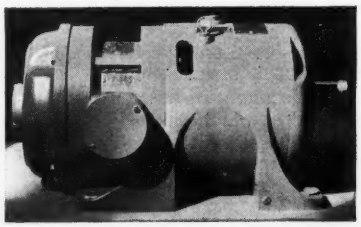
FOR OBSERVING combustion conditions in boilers and other types of furnaces the Plibrico Jointless Firebrick Co., Chicago, Ill., has developed an observation port which is provided with a divided cover, opened by means of a handle and

closed automatically the moment the handle is released by the operator. The overlapping sections of the cover close tight, practically eliminating any infiltration.

The port is also equipped with a glass to protect the eyes of the operator from possible injury. This glass is made of blue Pyrex to resist the heat and diffuse the glare.

Reliance Develops New Line of Generators

"GENERATORS" are units which combine in one compact frame, an electric motor and a speed reducer of suitable proportions. The Reliance Electric & Engineering Co. of Cleveland, Ohio, have recently placed on the market a new line of these units in sizes rated at ¾ hp. and up embodying several desirable features. These units have a cartridge type gear unit which carries all gears and bearings except the high speed pinion and bearing. The cartridge can be readily



removed without disturbing the alignment of any gears or bearings. A number of other features make these units easy to install and maintain and render them applicable to many different types of service.

Silent Base with New Quiet Ventilating Fan

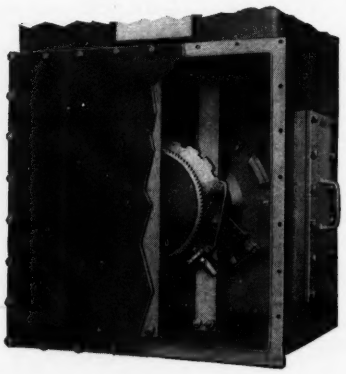
TO REMOVE the last traces of motor hum, which normally is picked up and magnified by the fan base and foundations, an audiometer was used in perfecting the Buffalo silent floating base, designed by Buffalo Forge Co., Buffalo, N. Y. This provides a practical, inexpensive means of insulating a fan and its driving motor from building foundations. Flexible rubber insulators, so designed that there is no metal contact between bolts holding down base and fan, provide a damping effect.

Rubber used in these insulators is in shear which is considered better than in compression as the life of the rubber is maintained over a long period.

A New Type Feeder Regulator

ALLIS-CHALMERS MFG. CO., Milwaukee, has developed a new type automatic feeder voltage regulator for applications where the induction type of regulator has heretofore been used. In addition the Allis-Chalmers unit can be used on higher operating voltages than those for which the induction regulator can be economically designed.

The equipment operates on the basis of an automatic tap changing device with suitable transformers,



all built into a small compact unit. This fills a long felt need for more economical and more efficient regulation of small capacity feeders. The equipment is suitable for either indoor or outdoor application and for single phase or three phase operation.

Check Valve Controls Pump

CHECK VALVE equipped with a mercoid flow switch has just been introduced by Barrett, Haentjens & Co., Hazleton, Pa., to shut down a pump if it loses its water during operation. The switch is connected into the low-voltage coil of the motor starter and is actuated by the valve flap. When the pump is in operation and delivering water, the flow through the valve raises the flap and closes the switch. When the pump loses its water the flap falls, the switch opens, and stops the pump.

BUFFALO PUMPS, Inc., Buffalo, N. Y., has developed a new single-suction pump with built-in self primer. For liquids not clear, the open type impeller is supplied; for clear liquids, the enclosed type. Capacities are up to 450 g.p.m. for heads up to 150 ft.

CHISHOLM-MOORE Hoist Corp. announces a new 2-speed wire rope drum hoist for limited head room, controlled by pendant hand chains in capacities from 3 to 30 t. Low speed for maximum loads, high speed for light loads, disc brake, cut gears, grease bath lubrication of moving parts are some of the features.

It Costs $11,280,000 Per Pound

"FINE AS A HAIR" is a crude comparison to the wire used in the new 1/100 ampere Instrument Littelfuses. This wire is some 30 times finer than the average human hair—the finest wire in commercial use in the world. It is a platinum wire, invisible to the naked eye, and so fine that 13,300 can be laid side by side on a one inch space. One pound of platinum drawn into this wire is 25,100,000 feet long, 4,750 miles or more than the earth's radius. Its cost is $11,280,000 per pound!

This wire is used only in the very smallest Littelfuses. The latter,

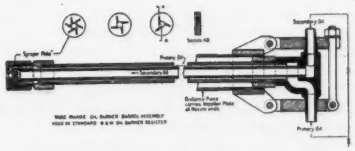
however, are made in larger sizes for a variety of purposes. Principally, however, they are designed to furnish inexpensive protection to that class of delicate electrical equipment operating principally in the range below one ampere, delicate instruments, vacuum tubes, etc.

They are constructed to have the minimum time lag possible to produce in a commercial fuse. It is this high speed characteristic that is most important in the protection of delicate equipment. It may seem unreasonable that a 1/32 amp. Littelfuse will protect a 1 milliampere meter, yet this protection is real.

These Instrument Littelfuses are made by the Littelfuse Laboratories, 1772 Wilson Avenue, Chicago, and are made in 1/100, 1/32, 1/16, 1/8, 1/4, 3/8, 1/2, 3/4, 1, 1 1/2, and 2 amp. capacity to protect any delicate instrument.

New Wide-Range Oil Burner

AN OIL BURNER that can be easily and quickly adjusted to operate efficiently over a wide range of capacities and that has operated very satisfactorily in service, has recently been put on the market by Babcock & Wilcox Co. The barrel assembly of the burner, which is known as the B. & W. Wide-Range Mechanical Atomizing Oil Burner, is shown in the figure. This barrel assembly is used in the standard B. & W. Mechanical-Atomizing Oil Burner register or as the oil burning element of the B. & W. Multifuels Burner. Fuel oil is delivered to the burner tip through two passages, an outer annular passage carrying the primary oil stream and the center oil barrel carrying the secondary oil. Both primary and secondary oil



meet at one nozzle and a sprayer plate at the burner tip. Changes in capacity with a given nozzle and sprayer plate are secured by operating at low capacities with primary oil alone, and at higher capacities with primary and secondary oil together. A capacity variation of four to one with any one combination of a sprayer plate and its nozzle may be secured.

Small Pumps

COMPLETE NEW LINE of turbine pumps has just been announced by Roots-Connersville-Wilbraham, Connersville, Ind. These pumps are suitable for handling even small quantities at high heads, capacities ranging from 5 to 300 g.p.m. at heads up to 350 ft. This pump uses a patented taper-edge impeller which makes it possible to vary the quantity while the pump is running. There is a slight increase in capacity as the head falls, with a noticeable decrease in the power consumption. The taper-edge impeller may be adjusted to give the volume required at lower heads while taking full advantage of savings in power consumed. R-C-W turbine pumps are furnished in corrosion resisting metals or alloys, thus adapting them for service in many difficult industrial applications.

Oil and Gas Power Meeting

THIS YEAR the Sixth National Meeting of the Oil and Gas Power Division of the American Society of Mechanical Engineers will be held in the Ritz-Carlton Hotel, Atlantic City, August 23 to 26. A very comprehensive program has been arranged, the scheduled sessions in general being confined to one a day. The papers include: Welding of Diesel Frames and Parts by Everett Chapman; Causes and Effects of Pressure Waves in Fuel Injection Systems by Ralph Miller; Reducing the Performance of a Solid-Injection Engine to Standard Conditions by H. A. Everett; Supercharging of Diesel Engines by Charles G. Curtis; Controlled Turbulence by M. S. Huckle and C. F. Taylor; Low Compression Oil Engines by Frederick Dutcher; Diesel Plant Operation by Ralph Troseth; and the Annual Report of the Sub-Committee on Oil Engine Power Costs by M. J. Reed.

Dr. Edward F. Miller

DR. EDWARD F. MILLER, a leading national authority on steam power engineering, and for the past 47 yr. on the teaching staff of the Massachusetts Institute of Technology, died at Newton Center, Mass., on June 12. Professor Miller was born in Somerville, Mass., in 1866, and was educated at the Institute. He received an appointment to its instructing forces immediately after graduating. From 1905 to 1911 he was professor of steam engineering and upon the retirement of the late Professor Gaetano Lanza in the latter year was made head of the mechanical engineering department, which post he occupied at the time of his death. Professor Miller headed the government's eight schools for marine steam engineers during the world war, and later was commissioned a colonel in the ordnance department of the army. He had many connections with technical societies both local and national.

James A. Shephard

JAMES A. SHEPHARD died at 69 yr. of age on Saturday, June 10 at his summer home, Kayutah Lake, New York.

In the year 1880, in partnership with his father and brother, Mr. Shepard established a foundry and machine shop in Montour Falls, under the name W. H. Shepard & Sons, for the manufacture of agricultural implements and for producing special castings. Several years later the name was changed to Havana Bridge Works, and engaged in the fabrication and building of steel bridges, and structural steel work. The bridge company was sold in 1903, and Mr. Shepard founded the General Pneumatic Tool Co., which later became the Shepard Electric Crane & Hoist Co. Several years ago the Shepard Company purchased the Sprague Electric Hoist Co. and the Niles Crane Company, and reorganized under the title Shepard Niles Crane & Hoist Corp. Mr. Shepard was actively engaged with this company as Vice President and consulting engineer up to the time of his death.

News From the Field

THE BROWN INSTRUMENT Company, Philadelphia, Penna., has developed a new type of battery for use with the Brown Potentiometer, which eliminates frequent standardizing. This new battery, the Brown Compensated Air Cell, having a constant current output and a life of over 2½ years, assures the potentiometer user of continuous accuracy with minimum attention. It can be used with all types of Brown Potentiometers. A bulletin describing the Brown Air Cell can be obtained from the manufacturer.

CHARLES M. BOLING, representing The Dampney Co. of America, moved from Detroit, Michigan, to Cleveland, Ohio, on June 1. From Cleveland he will continue to cover the Detroit territory as heretofore.

ANNOUNCEMENT is made of the Third International Heating and Ventilating Exposition to be held in Grand Central Palace, New York City, February 5 to 9, 1934. The conduct of the exposition will be in charge of the International Exposition Co. of Grand Central Palace, New York, and will be under the personal direction of Charles F. Roth.

NORTHERN EQUIPMENT Co., Erie, Pa., announces the appointment of C. H. Wilson, 1403 Park Boulevard, Troy, N. Y., as sales representative in the Albany district.

APPOINTMENT of several new agencies for the sale of its line of safety valves, steam gages and kindred appliances has recently been made by The Ashton Valve Co., Cambridge, Mass., as follows: Power Equipment Co., Memphis, Tenn.; O'Brien Equipment Co., St. Louis, Mo.; Rossman Industrial Supply Co., Seattle, Wash.; Garrett Burgess, Inc., Detroit, Mich.; Proctor Engineering Co., Inc., Baltimore, Md.

ANNOUNCEMENT that the location of the main office and assembly plant of the Westfalia Separator Co., Inc., has been changed from 11 West 42nd Street, New York City, to 30 Orange Street, Bloomfield, N. J., has been made by C. L. Patterson, Vice President and General Manager.

CHANGES AND PROMOTION: in personnel, as announced by E. F. Houghton & Co. of Philadelphia, Pa., are as follows: Louis E. Murphy, president since 1929, continues in that capacity. Major A. E. Carpenter, first vice-president and treasurer, was elected general manager. George W. Pressell, second vice-president and secretary, resigned the secretaryship and was elected assistant general manager and director of sales. Dr. R. H. Patch, director of plants, has been elected treasurer. A. E. Carpenter III, assistant to general sales manager, was elected secretary. George S. Rogers, formerly assistant general sales manager in charge of the St. Louis and Chicago offices, was appointed general sales manager with headquarters in Philadelphia.

ANNOUNCEMENT HAS JUST reached us of the formation of Harry Reid and Company, Inc., at 84 William Street, New York, N. Y., to engage in operation, engineering and supervision of public utility companies. They are prepared also to furnish reports and plans on construction, maintenance, rates, taxes, recapitalizing and reorganization of utility companies. Associated in this organization with Harry Reid are Alan E. Burns, Ralph C. Roe, David W. Jones and Edward C. Isele.

The organization of this company by these men is of considerable importance because all of them have had broad experience in the different phases of public utility operation including financial and valuation matters, tax cases, rate cases, both business and engineering operation and engineering construction in all its phases. In a former organization they were responsible for the design and construction of the South Amboy and Bremo stations, both of which were outstanding in the excellence of their design. They are equally experienced in the engineering of transmission facilities.

THE METALLIZING CO. OF AMERICA, Los Angeles, Calif., has recently issued a booklet dealing with the metallizing process, its applications, advantages, and accessory equipment.

DESIGN AND CONSTRUCTION features of Westinghouse Heat Exchangers are described in a recent publication issued by the Westinghouse Electric and Manufacturing Company. A number of heat exchanger construction features have been developed and perfected which contribute to low installation cost, reduced maintenance, ease of cleaning and unusual reliability. A new type of seal for the edges of removable longitudinal baffles, and improvements in baffling that increase the efficiency of heat transfer are but two of the features described in the publication.

GOETZE GASKET & PACKING CO., New Brunswick, N. J., is distributing a recently published leaflet illustrating and describing the many forms of metallic gaskets manufactured by this company and pointing out the specific uses for which the gaskets were developed.

WORK HAS commenced on the new power plant of the Jewell Ridge Coal Corp., at Richlands, Virginia. This plant is 6½ mi. from the mine and power will be transmitted at 13,200 v. to the mine. This was required by the lack of water at any closer location. The plant consists of two 1000-kw. Westinghouse turbines, 225 lb., 150 deg. superheat; condensing 2-in. back pressure; 3 phase, 60 cycle, 2300 v. generators. Boilers erected and set by James T. Castle, Pittsburgh, Pa. Transformers by Westinghouse, Building and Foundations by B. F. Parrott & Co., Roanoke, Va. The consulting engineer is Edward R. Feicht, of Bala-Cynwyd, Pa., and Jewell Ridge, Va.

JOHN HUNTINGTON POLYTECHNIC INSTITUTE, Cleveland, O., will conduct another advanced welding course which will start on July 10. The course is designed to give engineers and experienced operators an opportunity for a week's intensive study from both the practical and theoretical standpoints. Both day and evening sessions will be held which will include practice, demonstrations and lectures on welding machines, electrodes and automatic welding. The only charge for the course is for materials used in practice.

AT A RECENT meeting of the Board of Directors of the Bayer Co., of St. Louis, Mo., Fred W. Linaker was elected vice-president. Mr. Linaker was, for many years, chief engineer and lately vice-president of the Vulcan Soot Cleaner Co. In joining the Bayer organization, Mr. Linaker brings with him many of his patents, thus broadening the scope of the Bayer Co.

TESTS OF ANCHORAGES for Reinforcing Bars, by Chesley J. Posey, is the title of the 31 pp. paper bound Bulletin No. 3 published by the University of Iowa, Iowa City, Ia., and selling for 50c. Investigations cover hooked anchorages (bent over 12 times the diameter of the bar) and straight embedments of specially roughened bars. The most satisfactory anchorage tested during four years investigation was in straight embedment of plain round bar, the surface of which had been roughened by indentations made with a blunt cold chisel.

For the Engineer's Library

THE TECHNICAL MAN SELLS HIS SERVICES. By Edward Hurst. Published by the McGraw-Hill Book Co., Inc., New York, N. Y. Size 5½ x 8 in., cloth, 239 pp. Price, $2.00.

During this period of unemployment this book should spread a ray of hope even though as the author states it was written to help but a small section of the unemployed—the technically trained graduate. Well written in an interesting style and based on 18 yr. experience in helping graduates find jobs, the book makes good reading even for those not seeking a job. Many of the case studies are presented as short biographies with intimate side lights into many of our industries.

INDUSTRIAL TEMPERATURE and Humidity Measurement and Control. By M. F. Behar. Published by Instruments Publishing Co., Pittsburgh, Pa. Size 6 by 9¼ in., cloth, 411 pp. Price, $4.00.

This handbook comprises parts 2 and 3 of the Manual of Instrumentation and may conveniently be divided into four sections: thermometry; pyrometry; automatic temperature control; and humidity measurements and control. Throughout, the book has been prepared from the standpoint of industry rather than of the laboratory and therein lies its chief value to industrial engineers. It supplies first hand information on hundreds of modern commercial instruments and formulates principles of measurement and control from the practical dollars and cents standpoint of industry.

ELEMENTS OF POWER GENERATION. By Arthur M. Greene, Jr. Published by John Wiley & Sons, Inc., New York, N. Y. Size 6 by 9 in., cloth, 302 pp. Price, $3.25.

An unusual book in that no effort is made to include theory, the intention being to familiarize the reader with the appearance, function and operation of equipment used in power generation. The primary object is to give the reader an engineering vocabulary which will aid later in theoretical studies. Significant words and statements throughout the book appear in bold face type, thus emphasizing to the unfamiliar reader the items to be remembered.

VOCATIONAL GUIDANCE IN ENGINEERING LINES. Sponsored by the American Association of Engineers. Published and sold by The Mack Printing Co., Easton, Pa. Size 6 by 9 in., cloth, 490 pp. Price, single copies, $2.50 postpaid; 10 or more copies, $2.00 each.

No review could do justice to this altruistic work undertaken by the society and carried forward by dozens of our leading engineers. It is an attempt to improve the quality of the engineering graduates by means of voluntary classification, a mental illumination of round holes so that the square pegs can see them in time to avoid dropping in. Although the primary object is to give the precollege student a bird's-eye view of all branches of engineering, its fundamental purpose and requirements, the book gives the general public a true impression of the modern engineer and his profession and will prove interesting and instructive reading to the engineer himself as the broad reaches of engineering today make it virtually impossible to know all of its many branches.

The first 19 chapters deal with the general branches of engineering, vocational guidance, ethics and compensation, while the remaining 46 chapters deal with specialties. Each chapter has been prepared by a specialist in his field, an engineer of national repute, who knows not only his subject but who is capable of expressing his thoughts in clear and concise English.

HANDBOOK OF MATHEMATICAL TABLES AND FORMULAS, by Richard Stevens Burington. Published by Handbook Publishers, Inc., Sandusky, Ohio. 8 in. by 5½ in., 251 pp, cloth bound. Price $2.00.

This book has been compiled to meet the needs of workers in chemistry, physics and engineering and the student of mathematics and other subjects requiring mathematical computation. In the first part of the book a careful summary of the more important formulas and theorems of algebra, trigonometry, analytic geometry, calculus and vector analysis is given. A comprehensive table of series, derivations and integrals is included. In the second part, the usual logarithmic and trigonometric tables up to five places, both in degrees and radians, are given. Numerous short tables are presented including those of natural logarithms, exponential and hyperbolic functions, probability integrals, logarithms of Gamma functions, interest and annuities as well as those of squares, cubes, and other numerical quantities.

ENGINEER'S MANUAL OF ENGLISH, By W. O. Sypherd and Sharon Brown. Published by Scott, Foresman & Co., 623 So. Wabash Ave., Chicago. 6½ in. by 4½ in., cloth bound, 526 pp. Price $2.00.

As a practical guide for all technical writing which the engineering student may need to do, while in college and later in connection with his professional duties, this book meets a definite need. It is unique in its concentration upon those phases of writing essential to the engineering profession. Every step is carefully explained and fully illustrated. The illustrative material is one of the noteworthy features of the book.

TREATMENT OF WATER FOR ICE MANUFACTURE, PART II. By Dana Burks, Jr. Published as Bulletin No. 253 by the Engineering Experiment Station, University of Illinois, Urbana, Ill. Size 6 by 9 in., 32 pages, paper bound. Price 45c.

Results obtained in a course of coöperative research investigation on the treatment of water for ice manufacture so as to make possible the production of ice of marketable quality. Results presented are a continuation of the former bulletin No. 219. As a result of the investigation it has been shown that the allowable limit of salt concentration in solutions to be used in the production of marketable ice at brine temperatures of 16 deg. F. may be extended to 1300 parts per million, instead of approximately 250 parts per million, the limit under operation previously standardized in the industry; and although successful utilization of solutions containing 1300 parts per million of dissolved salts has been shown to increase the production cost 6.8 per cent over that resulting from operation now standardized in the industry, the efficiencies offered by modernized operation more than offset this increase, and render the proposed methods economically attractive.

COPPUS ENGINEERING CORP., Worcester, Mass., has just issued Bulletin 166 describing the new portable gasoline engine driven cable manhole ventilator for ventilating and driving noxious fumes from confined working spaces.

UNDER THE title Water Power Equipment the Newport News Shipbuilding and Dry Dock Co., New York City, has published a book giving pertinent engineering data and illustrations of 29 important hydroelectric plants located in all parts of the world.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., has just issued its Leaflet 2159 describing its new single-stage water-cooled rotary air compressors. This covers a complete line of rotary air compressors and vacuum pumps of the multicellular, sliding-vane type, having a range of volumes from 50 to 2000 c.f.m., at pressures up to 150 lb. and vacuums up to 29.85 in. mercury.

IN A SERIES of booklets under the general title of Industrial Rehabilitation at Work, Republic Flow Meters Co., Chicago, Ill., has just published No. 3 of the series dealing with the cost records and control problems in a corn products plant.

PRODUCTS OF THE Baldwin Locomotive Works and Subsidiaries is the title of an interesting booklet which gives a short historical account of each of the following companies and a list of their products: Baldwin Locomotive Works; Standard Steel Works Co., Cramp Brass and Iron Foundries Co., Baldwin-Southwark Corp., De LaVergne Engine Co., Pelton Water Wheel Co., Whitcomb Locomotive Co., and Midvale Co.

"OXWELDING FOR GENERAL MAINTENANCE" is the title of a booklet published by The Linde Air Products Co., New York, N. Y., which describes the use of the oxy-acetylene process of welding and cutting in reclamation of broken and worn machine parts, alteration, fabrication and installation of equipment. Among the various plant equipment covered are piping, tanks and containers, machine elements, engine and pump parts, frames and conveying equipment. Repair of worn parts by bronze-surfacing and hard-facing is given special consideration. Among the many illustrations is a chart giving thirteen simple tests for identifying the more common metals

LEE B. METTLER CO., Los Angeles, Calif., has just issued a catalog on the Mettler Entrained Combustion Gas Burner in which the principles used and the details of construction are described. The catalog gives illustrations and data on many boiler plants using this type of gas burner.

WESTCOTT ORIFICE METERS for gas, oil, air, steam and fluids are described in catalog EG-2 just issued by the American Meter Co., Metric Metal Works, Erie, Pa.

YARWAY BULLETIN YB-2001 recently published by Yarnall-Waring Co., Philadelphia, Pa., is devoted to the Yarway-Becker Air Valve, useful for pneumatic tools of the portable type, having been particularly successful in mining work.

E. F. HOUGHTON & Co., Philadelphia, Pa., has just issued a wall chart 24 by 36 in. entitled "The Care of Leather Belts." The subjects covered by the chart are: How and When to Dress Belting. Belt Fastenings. How to Lace Belt. How to Put on a Belt. Tables Showing the Width of Belt Necessary for Any Drive. Mechanical Rules for Figuring Speeds, Pulley Ratios, etc.

AIR CONDITIONING for Health Comfort and Profit, an illustrated sixteen-page publication, has recently been issued by the Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa. This non-technical description of Westinghouse equipment gives interesting facts and information on the application and advantages of unit air conditioners.

STEEL TUBES, Inc., Cleveland, Ohio, a unit of Republic Steel Corp., has just issued a Handbook of Electric Weld Tubing which is the result of a serious attempt to establish standards for the electric weld tubing industry. The book describes briefly the method employed under the Johnston process together with engineering and standard practice information which will prove helpful as a guide to users of tubing.

FORCED DRAFT FANS of the new Rexvane design are described in detail with operating performance data in bulletin No. 391 published by the B. F. Sturtevant Co., Hyde Park, Boston, Mass. These fans were designed to meet the following basic requirements of the small forced draft fans: high speed, small size, quiet operation, reliable performance with good efficiency.

Power Plant Construction News

Ala., Dothan—Common Council plans extensions and improvements in municipal electric light and water plants, including installation of Diesel engine units and auxiliary equipment. Cost over $30,000.

Ala., Red Bay—Town Council plans installation of pumping machinery, 50,000-gal. capacity elevated steel tank and tower, and other mechanical equipment for new municipal waterworks. Fund of $55,000 has been secured for program.

Ala., Sheffield—Common Council has authorized a fund of $150,000, for a municipal electric light and power plant, and plans to begin work at early date.

Ariz., Phoenix—Phoenix Carbonic Ice Corporation, 131 West Jefferson Street, plans construction of new dry ice manufacturing plant, with carbonic gas manufacturing unit on adjoining site. Property has been acquired at Magnolia Street and Nineteenth Avenue. Cost about $50,000, with equipment.

Calif., Long Beach—Consolidated Aircraft Corporation, 2050 Elmwood Avenue, Buffalo, N. Y., plans installation of electric power equipment in new plant on 25-acre tract of land at Long Beach airport, recently acquired. A one-story boiler house is proposed. Entire plant will cost close to $200,000.

Calif., Los Angeles—Arthur E. Harvey 3875 Wilshire Boulevard, Los Angeles, architect, has plans under way for new brewery and ice-manufacturing plant in San Fernando Valley district, for company whose name is temporarily withheld, to include installation of electric power equipment, pumping machinery, ice and refrigerating and other mechanical equipment. Cost about $175,000.

Calif., Los Angeles—Pittsburgh Plate Glass Co., Grant Building, Pittsburgh, Pa., plans installation of electric power equipment in new three-story plant for paint and varnish manufacturing division, at Long Beach and Maie Avenues, Los Angeles. Company engineering department, address noted, is in charge. Cost over $75,000.

Colo., Aspin—Roaring Fork Electric Light & Power Co., Aspin, plans early construction of a new power transmission line with substation facilities to Twin Lakes district, about 21 miles. Cost close to $35,000. Durbin Van Law, C. A. Johnson Building, Denver, Colo., is consulting engineer.

Del., Wilmington—Board of Education plans construction of steam power plant for central heating service at new city high school group at Thirty-fourth and Monroe Streets, where tract of 23 acres of land has been acquired. Entire project will comprise several buildings, estimated to cost $1,500,000. E. William Martin, du Pont Building, is architect.

Fla., Winter Haven—Winter Haven Utilities Corporation, recently organized by C. H. Thompson and E. B. Walthall, Winter Haven, plans construction of an electric light and power plant for local commercial service. Cost reported over $90,000. A franchise has been asked.

Ill., Chicago—Hoffman Brothers Brewery, Monroe and Rockland Streets, recently acquired by new interests, plans installation of electric power equipment in connection with an expansion and modernization program, estimated to cost about $100,000.

Ind., Rockville—Common Council is having plans completed for a municipal electric light and waterworks station to cost about $45,000, and plans to begin work in near future. John M. Potz, Merchants' Bank Building, Indianapolis, Ind., is consulting engineer.

Ind., Vincennes—Old Vincennes Brewery, Inc., plans installation of electric power equipment, refrigerating, tanks and other mechanical equipment for an expansion and improvement program. Cost about $175,000. M. F. Strauch, 3863 Lincoln Avenue, Chicago, Ill., is architect.

Iowa, Shenandoah—Common Council plans early purchase of a new generator unit and auxiliary equipment for installation at municipal water plant for power service. A fund of $21,000 has been authorized.

Kan., Burlington—At recent special election, Common Council has been authorized to arrange a bond issue of $118,000, of which $85,000 will be used for construction of a new municipal electric light and power plant, and $33,000 for installation of a distribution system. Proposed to begin work on project at early date. E. T. Archer & Co., New England Building, Kansas City, Mo., are consulting engineers.

Ky., Fort Thomas—Common Council has surveys under way for a municipal electric light and power plant. Estimates of cost will soon be completed. Proposed to begin work on project in near future. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Md., Amcelle—Celanese Corporation of America, Amcelle, near Cumberland, plans installation of electric power equipment in new addition to rayon mill. Estimated cost over $75,000.

Mass., New Bedford—Arthur Rosenstein, 120 Milk Street, Boston, architect, has plans for extensions and improvements in brewing plant on Hillman Street, New Bedford, for company whose name is being temporarily withheld. Electric power equipment, mechanical-cooling, tanks and other equipment will be installed. Entire project will cost about $200,000.

Mich., Olivet—Board of Trustees, Olivet College, is planning extensions and improvements in power house at institution, including installation of new equipment. Cost close to $25,000. McColl, Snyder & McLean, Penobscot Bulding, Detroit, Mich., are consulting engineers.

Mich., Munsing—City Council has tentative plans under way for a municipal electric light and power plant. Estimated cost over $150,000. Alvord, Burdick & Howson, 20 North Wacker Drive, Chicago, Ill., are consulting engineers.

Minn., Ely—Common Council is considering construction of a steam power plant for municipal central heating station, including system in different parts of city. Estimated cost over $300,000, with equipment. Joseph Veranth is city engineer, in charge.

Mo., Moberly—City Council, Otto A. Swoboda, city clerk, is said to be considering installation of a municipal electric light and power plant. Cost estimated at more than $500,000, with equipment. Financing will be arranged in near future.

Ore., La Grande—Eastern Oregon Brewing Co., care of George W. Singer, La Grande, recently organized with capital of $250,000, plans installation of electric power equipment, tanks, conveyors and other mechanical equipment in new brewing plant. A boiler house will be built. Estimated cost about $100,000.

Ohio, Cleveland—Leisy Brewing Co., Cleveland, care of G. A. Mueller, 1346 Broadway, Detroit, Mich., architect and engineer, plans installation of electric power equipment, mechanical-cooling, tanks and other mechanical equipment in new brewing plant. A boiler house will be built. Entire project will cost close to $500,000.

Pa., Philadelphia—A. C. Gruenewald, 911 Dorset Street, has leased three-story building, 122 x 133 ft., at North American and Philip Streets, and will remodel and equip for brewery and ice-manufacturing plant, with installation of electric power equipment, tanks, conveyors, pumping machinery, ice-making machinery, etc.

Pa., Williamsport—Flock Brewing Co., plans installation of electric power equipment in connection with an expansion and modernization program. A bond issue of $190,500 is being sold, portion of proceeds to be used for purpose noted. H. F. William Flock is president.

Texas, Dallas—Pollock Paper & Box Co., 2236 South Lamar Street, plans installation of electric power equipment in new one-story addition, 40 x 200 ft. Cost about $30,000, with machinery. R. O. Jameson, Southwest Life Building, is engineer.

Texas, Fort Worth—B. H. Collier, 3801 El Campo Street, and associates are organizing a new company to construct and operate an ice-manufacturing plant. Site will soon be acquired. Initial plant will be equipped for a capacity of about 100 tons per day, and will cost approximately $85,000, with machinery. Mr. Collier will be treasurer of new organization.

Texas, Texas City—Pan-American Petroleum & Transport Co., 122 East Forty-second Street, New York, N. Y., plans construction of power house at new oil and gasoline refining plant at Texas City, where tract of about 250 acres of land has been purchased. Project will include pumping plants and large steel tank oil storage and distributing units. Entire plant will cost over $7,000,000.

Va., Abingdon—City Council has preliminary plans under way for a municipal electric light and power plant, and waterworks. Cost over $250,000, with equipment. J. B. McCrary Engineering Corporation, Atlanta, Ga., is consulting engineer.

Wis., Knowlton—Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., and Wisconsin Valley Improvement Co., Wausau, associated, are planning construction of a hydroelectric generating plant on Wisconsin River, near Knowlton, in connection with a water storage and development project. Work will include power dam, generating station, transmission lines, power substations and switching stations, and other electrical structures, estimated cost about $1,644,000. Entire project will cost about $5,000,000. Application has been made to state for permission.